ELECTRICAL ENGINEERING

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The Cover: Steel struts are welded in a 40-ton cast-iron upper-exhaust hood by workman at General Electric Company's turbine factory, Schenectady, N. Y. Resembling an igloo, the hood is part of the first of six 200,000-kilowatt steam turbine-generators being made for Ohio Valley Electric Corporation's new Clifty Creek plant near Madison, Ind. The Ohio Valley Electric Corporation was organized by 15 private utilities to generate electric power for the Atomic Energy Commission's project near Portsmouth, Ohio.

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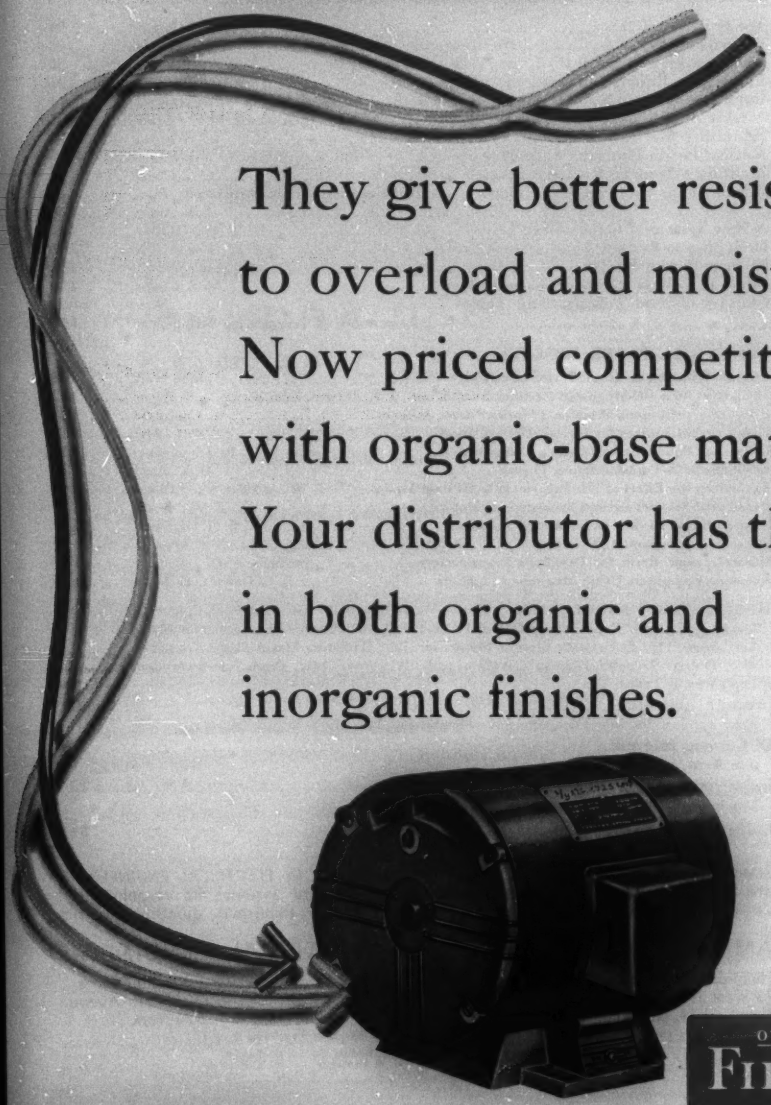

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HIGHLIGHTS.....

We're in the Red. W. J. Barrett, Treasurer of AIEE, discusses the current deficit, and tells what measures need be taken to correct the situation. A chart gives the General Fund Balance for the beginning of each month for the fiscal years, 1953–1954 and 1954–1955. This problem should be of concern to every AIEE member (*p. 95*).

Survey Reports. The AIEE Committee on Planning and Co-ordination has tabulated the results of the questionnaires recently sent to AIEE members to investigate employment conditions. The details are reported graphically in terms of per cent. (*pp. 96–7*).

Nuclear Power Plants for Ship Propulsion. Proposals made by industry study groups give insight into use of atomic power for propulsion of ships (*pp. 116–21*).

A New System of Logarithmic Units. Various units, as the decibel, have been used in connection with a physical quantity; each satisfies the requirement of convenience. Often the units are used in a new field in which they do not apply, which leads to confusion. Thus there is a need for a system, as described (*pp. 135–7*).

Corrections. In the January issue, Engineering Developments, 1954, 300 miles instead of 3 miles was given as the maximum depth which the transatlantic cable is laid; and the view of the chassis of the color television receiver and black-and-white television receiver was through the courtesy of Westinghouse Electric Corporation instead of General Electric Company, as given. In the figure on page 40 in Ten Founding Fathers of the Electrical Science—X, the date is given as 1988, instead of 1888.

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The First Five Years of Professional Development. President Monteith, as chairman of the Training Committee for the Engineers' Council for Professional Development, reviews the progress of the trial run of its professional development program in Cincinnati. This has been made possible through the co-operation of industry, universities, and professional societies. Similar plans will be carried out in other cities throughout the country in the near future (*pp. 98–100*).

Educating Electrical Engineers to Exploit Science. A review of the growth of engineering and an examination of the nucleus of electrical science preface a discussion of the suggested break with tradition as reflected in the revised curriculum at one outstanding educational institution (*pp. 110–5*).

Organization Planning—The Hard Work and Common Sense Approach. Organizational planning and manpower control functions are performed in one oil company by a Department on Organization. In this company planning aims to place the responsibility and accountability in the hands of the people required to carry on the activities of the company (*pp. 130–5*).

Employers, Ethics, and Novice Engineers. In this article, a comparison is drawn between the professional standing of a young engineer and an interne in the medical profession. It is discussed as to how employers can help raise the standards of the young engineers (*pp. 101–2*).

Nuclear Power Reactors. This is the second part of a 2-section article on nuclear power reactors. It describes two reactor types, reactor technical problems, and costs in making use of this new type of power. A large percentage of the power plants may be nuclear powered by 1975 (*pp. 144–9*).

Lighting a Modern Refinery Process Unit. When any plant has outdoor equipment which functions on a round-the-clock basis, good engineering demands that adequate illumination be provided. The lighting principles covered in this article obtain for any exterior operation where men have to see at night (*pp. 124–8*).

Safety in College Electrical Laboratories. When electrical engineering students first begin their work with electric machinery, they should be warned of the lurking hazards. If good safety habits are formed early, fewer accidents will occur during their careers (*pp. 151–3*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Implementation of a Research Program for the Electric Utility Industry. Various methods of conducting research planning for system engineering, and the desirability of an industry-supported laboratory is emphasized. Such a research program would encourage greater interest in the power industry among engineering students (*pp. 104–9*).

Glossary of Some Telemetering Terms. The Joint Subcommittee on Telemetering Terminology of AIEE and Institute of Radio Engineers (IRE) has prepared a glossary of definitions. A few definitions are known to be controversial, but it is hoped that a publication of the terms will foster discussion and hasten agreement (*pp. 153–6*).

Designing to Reduce Maintenance Cost. Maintenance in production must be planned, and the shop must be well equipped and have trained personnel to be effective. In this article, an analysis is made of some of the causes for maintenance on electric systems, as well as corrective measures that must be taken into consideration for reduced maintenance costs (*pp. 139–41*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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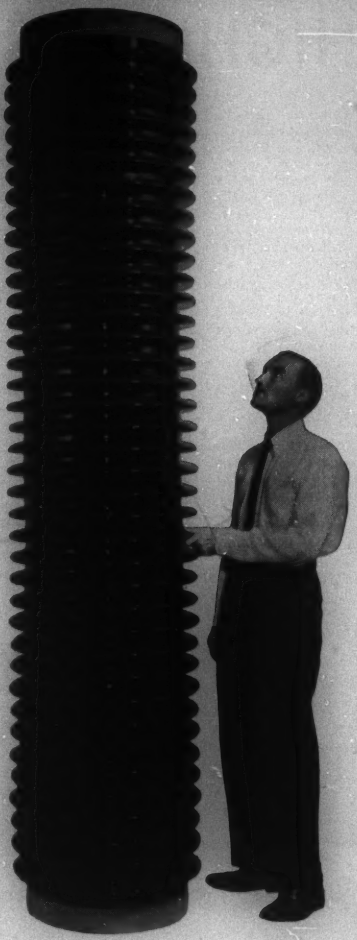

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We're in the Red

W. J. BARRETT
TREASURER AIEE

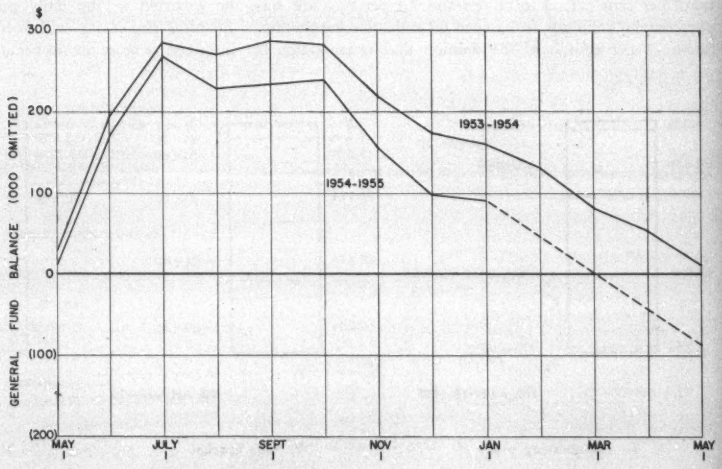
IN his article in the January issue of *Electrical Engineering*, C. S. Purnell, Chairman of the Finance Committee, pointed out that the budget for the year beginning October 1, 1954, anticipates a deficit of about $106,000. In the calendar of the Institute, a budget year overlaps portions of two fiscal years. It has been done that way in an attempt to make the budget year coincide approximately with the period during which the Institute committees function. The fiscal year starts on May 1. It is the year for which the member pays his dues and in return receives the publications and other benefits of membership.

With a total turnover in the order of a million and a quarter dollars per year, the balance in the treasury ranges from almost nothing to roughly $300,000, and follows a fairly well-defined pattern throughout the fiscal year. This is because the dues are paid very largely within the months of May and June, and to a lesser degree in July, August, and September. Expenditures are more nearly uniform throughout the year, and usually have minor peaks in the months of May, July, and October. The accompanying diagram shows the balance in the General Fund of the Institute on the first of each month through the present fiscal year up to January 1, 1955, and through all of the preceding fiscal year, 1953–1954.

In recent years, it has become more and more difficult to make ends meet. In the fiscal year ending May 1, 1954, there was an operating deficit of some $17,000 which left us with $8,710.35 in the General Fund to start the present fiscal year. The curve shows that at no time this year have we been as well off as we were 12 months earlier, and the position has been getting steadily worse. The dash line is an attempt to forecast in a very rough way what may happen between now and May 1. If it is borne out by experience, there will be a deficit for the fiscal year of approximately $100,000. Furthermore, the General Fund balance will be completely wiped out by the end of February.

When the Board of Directors meets in New York on February 3 during the Winter General Meeting, I shall have to ask them for authority to dispose of some securities now held in the Reserve Capital Fund in order to get cash with which to pay our bills and the salaries of our Headquarters staff. This will mean a reduction in the funds which have been carefully laid away over the years to take care of just such an emergency as this. However, it is believed that we will need a substantial capital sum in connection with the long-hoped-for replacement of our present obsolete and inadequate Headquarters building. It is imperative that operations in the red, such as we are experiencing at the present time, be true emergencies which occur only rarely and under circumstances which cannot reasonably be guarded against.

Obviously, the relation between income and expense must be improved substantially and at once. Steps have already been taken to derive some additional revenue from advertising in Institute publications. This is one of our major sources of income. The other major source of income is the payment of dues by the members. It is imperative that the dues be increased as of May 1, 1955, which will be the first increase for the great bulk of our membership in over 50 years.



Balance in the General Fund of the Institute on the first of each month for fiscal years, 1953–1954 and 1954–1955. (The dash line is a forecast of the monthly balance between January 1, 1955, and May 1, 1955)

Returns on 1954 Employment Questionnaire

L. F. HICKERNELL
CHAIRMAN PLANNING AND CO-ORDINATION COMMITTEE

Answers to the questions on Employment Conditions recently sent to AIEE members have been tabulated, and the results are given in this summary. According to the returns, participation represented a good cross section of membership throughout the country.

THE Committee on Planning and Co-ordination has completed the tabulation of 24,769 returns from the questionnaire on Employment Conditions recently sent to 44,095 members of AIEE in the United States and territories. Returns continue to trickle in. Those tabulated so far represent a response of over 56 per cent.

The details are reported here graphically in terms of the per cent of those answering each question. The number of returns not showing an answer is noted in each case.

That the participation was general throughout the country is shown in tabular form in question 4 by the comparison between the per cent of returns received and the per cent of the membership resident in each state. The distribution by membership grades and age brackets likewise indicates a good cross section of the membership. Responses from members under 40 years of age account for 57 per cent of the total.

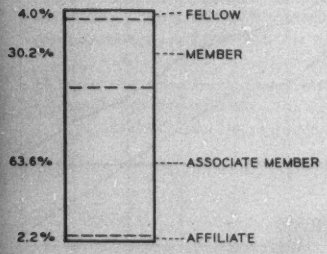
A little over half of the respondents hold state licenses or are "engineers-in-training." Over three-quarters are engaged in industry (including utilities). Five and one-tenth per cent belong to unions and 9.1 per cent are employees who definitely feel a need for collective bargaining. Some 71 per cent hold the opinion that unionization is incompatible with the individual responsibility and independent judgment required of an engineer.

Such are the over-all findings depicted graphically in some detail in this first report to the membership. Continuing studies, using tabulating machinery, will classify the answers by age, grade, geographical, and occupational groups.

Over 7,000 members expressed or amplified personal opinions in response to the invitation extended by question 12. These have been roughly classified into some 30 categories and will serve as a basis for future discussions. Questions 13–17 inclusive, which have to do with "Associations for Engineers," do not lend themselves to analysis by tabulating machine methods; therefore, the answers cannot be reported at the present time.

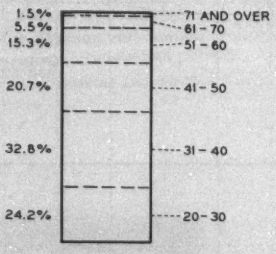
The returns from this general survey correspond closely with the indications received from the trial run conducted in the Lehigh Valley Section last spring which covered about 1 per cent of the total Institute membership. This suggests the possibility of effectively surveying membership opinion on important questions by modern sampling methods.

The gross counts of the returns on the first 11 questions reported here have been made available for combination with the returns reported by other major engineering societies from similar questionnaires. These combined figures showing returns from 64,206 engineers will probably be reported in the daily public press late in January. *Electrical Engineering* will keep the membership of AIEE informed as more details become available.



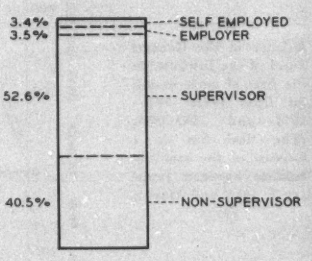
NO ANSWER—139

1. Membership grade



NO ANSWER—76

2. Age bracket

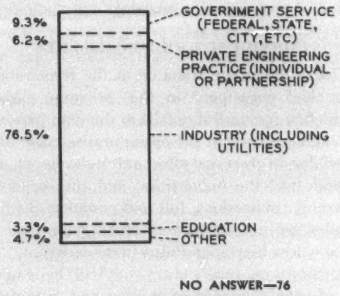


NO ANSWER—428

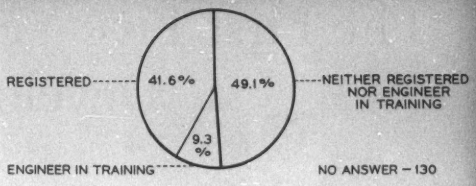
3. Employment status

4. State or territory in which residence is maintained

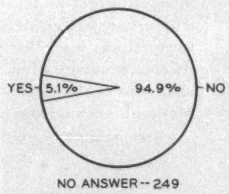
State or Territory	Population 1950 Census (in thousands)	Number of Members in State	Per Cent of State to Total Membership	Per Cent of State to Total Answer
N.Y.	14,830	7,329	15.3	14.25
Pa.	10,498	4,245	9.0	9.92
Calif.	10,586	4,079	9.0	9.35
Ohio	7,947	2,841	6.0	6.86
Ill.	8,712	2,063	5.4	5.95
Mass.	4,691	2,054	4.3	4.76
N.J.	4,835	1,954	4.1	6.01
Tex.	7,711	1,675	3.5	3.69
Mich.	6,372	1,369	2.9	3.35
Wis.	3,435	1,119	2.3	2.57
Wash.	2,379	1,104	2.3	2.62
Mo.	3,955	1,103	2.3	2.33
Md.	2,343	1,064	2.2	2.93
D.C.	802	893	1.9	0.83
Ind.	3,934	884	1.8	2.05
Conn.	2,007	752	1.6	1.88
Tenn.	3,292	687	1.4	1.65
Oreg.	1,521	571	1.2	1.20
Minn.	2,982	496	1.0	1.11
Fla.	2,771	487	1.0	1.03
Okla.	2,233	476	1.0	1.11
Va.	3,319	464	1.0	1.41
La.	2,684	463	1.0	1.04
Colo.	1,325	427	1.0	0.98
Ala.	3,062	426	1.0	1.04
Ga.	3,445	394	1.0	0.94
N.C.	4,062	387	1.0	0.91
N.Mex.	681	278	0.6	0.66
Ky.	2,945	269	0.6	0.59
Ariz.	750	244	0.5	0.56
Iowa	2,621	243	0.5	0.64
W.Va.	2,006	234	0.5	0.54
Kans.	1,905	227	0.5	0.78
Nebr.	1,326	210	0.4	0.51
S.C.	2,117	201	0.4	0.53
Ark.	1,910	181	0.4	0.43
Del.	318	178	0.4	0.39
R.I.	792	139	0.3	0.35
Mont.	591	122	0.3	0.23
Miss.	2,179	117	0.2	0.26
Utah	689	117	0.2	0.30
N.H.	533	95	0.2	0.28
T.H.	500	89	0.2	0.17
Idaho	589	62	0.1	0.10
Maine	914	53	0.1	0.19
Nev.	160	50	0.1	0.13
P. R.	2,211	46	0.1	0.06
Wyo.	291	46	0.1	0.08
N. Dak.	620	45	0.1	0.11
S. Dak.	653	45	0.1	0.13
Vt.	378	40	0.1	0.09
Alaska	129	28	0.1	0.05
C. Z.	53	6		0.004
Canada		2,087	4.4	
Others		2,125	4.4	
Total		47,923		



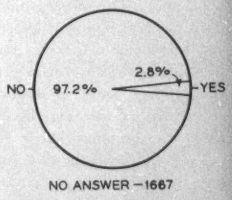
6. Field of service



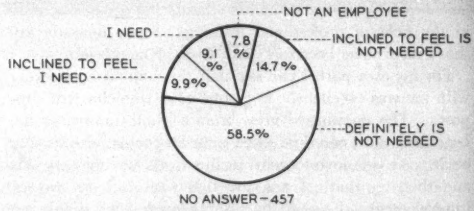
5. Registered professional engineer



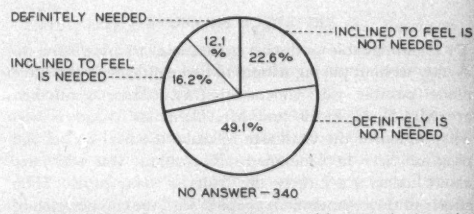
7. Member of union



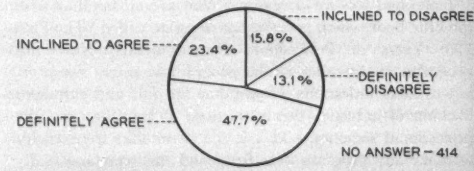
8. Not a union member, but represented by union



9. As an employee, need for collective bargaining



10. Regardless of employment status, need for collective bargaining



11. The individual responsibility and independent judgment required of an engineer are incompatible with unionization

The First Five Years of Professional Development

A. C. MONTEITH
PRESIDENT AIEE

The trial run of the Engineers' Council for Professional Development's professional development program in the city of Cincinnati, Ohio, which has the full co-operation of industry, the universities, and the professional societies, is receiving nation wide attention. As honorary chairman of the Training Committee, President Monteith reviews the objectives, activities, and progress of the Council in this undertaking.

THIS meeting is indeed a milepost on the broad road of professional training being spearheaded by Engineers' Council for Professional Development (ECPD). I think it should go down in the annals of ECPD as Cincinnati Day.

I clearly recall the circumstances surrounding my initial association with this activity. It was just 5 years ago that Mr. J. W. Parker urged me to accept the assignment of organizing what now constitutes the Training Committee of ECPD. The committee's assignment was to gather facts and explore possible means of stimulating greater activity in the field of professional training. I can honestly say that I have never been sorry that I was given this job.

For my own part, I can say that the committee working with me was excellent. Everyone gave wholehearted support. The committee grew from a small number at the beginning until one time when some 80 people were serving on it. As we move forward in this work, we must try this and then try that. I am sure that with each try we see improvement. I would be disappointed if we didn't see progress. It seems appropriate at this time to review our progress to date.

REVIEW OF PROGRESS

IT is unthinkable to discuss professional training here today without paying tribute to two gentlemen who have made possible this Cincinnati Day. These gentlemen are Mr. E. S. Fields and Mr. Cornelius Wandmacher. They accepted the challenge to make the trial run of our program here in Cincinnati. The things you will hear about today are largely the fruits of their labor. The efforts of these gentlemen, coupled with the co-operation of the University of Cincinnati and the business people in this city, have made it possible to see this program properly and effectively launched.

I mention this for a reason. You are all familiar with the Blue Book which presents our program called "The First Five Years of Professional Development." Now this program, or any other similar program we might assemble, is worthless unless the project has the full and sustained backing of industry, the institutions of learning, and the professional societies. This is the team that is necessary to make any program bear fruit, and this team has really clicked in Cincinnati.

I would like to ask two questions in connection with the content of this Blue Book. First, what is the basic objective of our program? Second, why do we call it "The First Five Years?"

The answer to the first question is both simple and direct. The one objective of this whole program is the development of men. If we keep that one objective clearly before us and direct our efforts toward that one objective, there is absolutely no question about the results of our planning, our co-operation, and our hard work. The program will succeed because it will prove to be extremely helpful to those men who need it, and very satisfying to those men who labor over it. Mr. Alfred P. Sloan of General Motors Corporation made a statement at a stockholders' meeting that brings this point clearly into focus. He said, "In our own great industrial organization and in the vast industrial structure of the United States, the same bricks, the same mortar, the same machine tools are available to everyone. The difference between a successful and an unsuccessful corporation lies in the men who comprise it." This is a vital thought and points up the answer to the second question—why do we call our program "The First Five Years?"

The success of any venture depends upon the development of men. This development takes time. The first 5 years of a man's professional life are the most important in the shaping of his career. When he leaves the campus, his career horizons take on new light; his ambitions cease to be dreams. He must immediately set about to reappraise his objectives and lay plans to meet them. In this, he needs help and so we have chosen to concentrate our efforts during this period of professional awakening.

INDIVIDUAL'S RESPONSIBILITIES

NOW let us direct our attention to the responsibilities of the chief participant in this program. Above all others, the first responsibility falls to the man himself. He must be willing to accept the opportunities made available to him, willing to exert real effort at self-development. Although industry, the universities, and the societies must assume certain obligations, full and complete discharge of these duties are not worth very much if the man himself does not shoulder his responsibility in the program.

During the young man's years in school, he is under the tutelage of people capable of guiding and training young

Essential text of address presented before the 22nd annual meeting of Engineers' Council for Professional Development, Cincinnati, Ohio, October 28–29, 1954.

men. When he leaves school and joins the ranks of industry, he steps into a brand-new environment. This is a broad step and even though the orientation programs of industry alone may be quite effective, he still needs a helping hand across the broad gulf between college life and the embryo stages of a professional career.

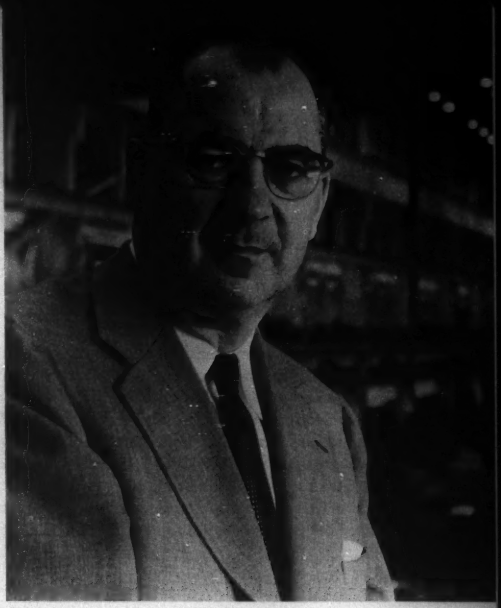
This is why I am so enthusiastic about a program for the first 5 years. During that period, the young man is on his own. He discovers that he has a lot of leisure time at his disposal, more than he has been accustomed to. He is free to choose whether he uses that time wisely or wastes it. It is here, during these crucial years, that we have a responsibility to guide him into the right paths of thinking. This responsibility we must accept. Continued effort on our part will fill a crying need.

This need has been driven home to me in recent months. As many of you may know, AIEE recently submitted a questionnaire to its membership. It deals with professionalism. I have had the pleasure of reading many of the letters that have come in as a result of this questionnaire. I am confident that some of the societies are beginning to become aware of the fact that there is a job to be done along professional lines as well as technical lines. A number of these letters point out quite emphatically that very little is being done to help the young man in his professional development.

It seems that the ECPD organization is very little known and very poorly understood among the members of the numerous technical societies. Before the first 5 years program can get going on a broad scale across the country, this situation must be rectified. We must conduct an educational campaign so that the purpose and basic objectives of ECPD and the objectives of this particular committee are understood. If we can find ways to insure this greater understanding, we will be on the road to broader acceptance of the responsibilities defined by our program. We will also be in a position to redirect some very dangerous tangential thinking that appears to have been developing in recent years.

I refer to the erosion in the thinking of our young men in so far as their professional attitude is concerned. It is quite obvious that some of our young men think too much in terms of increased security rather than in terms of opportunity. This may be a natural outgrowth of the stage of security thinking they have just come through. You and I have heard too many young men ask "What security is there in it for me?" rather than "What opportunities are available?"

This trend in the thinking of our young men must be changed. We all know that a man either goes ahead or he goes back; he cannot stand still. If we can get the young man to think in terms of moving forward, we will dispel a lot of troublesome thinking that is facing industry today. I mention industry because it has a very great stake in this problem. It can do a lot for these young people. But to do the most effective job, we, in industry, must be willing to stand up and be counted. We must hammer home by whatever means are at our disposal the basic truth that increased professional stature provides the only road to security.



A. C. Monteith

ECPD'S DUTIES

Now let's take a little closer look at some of the responsibilities of ECPD. First of all, we must recognize that it is our duty to keep the young man occupied. For that reason, I like the idea of getting started while he is still in school. He must not be allowed to leave school with the thought that his diploma marks the end of his journey in education.

Rather, it should be made clear to him that the sheepskin is only the foundation upon which he must continue to build and that the building must be done by himself. I cannot emphasize this point too strongly. He must be made to realize that the man who leaves school with a determination to continue self-improvement multiplies his chances for success many times. And, I am sure that if our young men of today are made aware of the helping hands awaiting them they will reach for them very eagerly and quickly.

It is our responsibility to make the young man realize that the benefits of all the efforts he puts forth accrue only to himself. Anything he can do to improve himself will either put him in a better position with his company or in an improved position to get a better job. I have heard young fellows say, "Why should I do this on my own time when it is only going to help the company?" We must make them realize that this attitude only undercuts their own future—that they are selling only themselves short.

In this whole effort, industry has much to gain. For this reason, I think industry must take the lead. Others, of course, have a stake in this but I think that if we in industry

recognize our responsibilities and take steps to do our part better, we will all benefit. A contented employee is always a better employee. His attitude is healthy and he is more inclined to think constructively about his professional development. We in industry must face our responsibilities in orienting and training the young man and in specializing him so that he can move into a productive position much more quickly.

We must also get our own house in order so that we can tell the colleges the kind of education we look for in the young man. This does not mean that we will ask for a "motor designer" or an "automobile designer." Instead, we will say, "We want a man with a good sound basic foundation in engineering and we will make him a specialist." If industry takes the responsibility for specialization, much confusion will be cleared away and the educational system of our country will be greatly improved.

The engineering societies have a part in the solution of this problem too. They must help the man develop professionally, give him a guiding hand, and assist him in becoming an integral part of his community. I feel that this area has received far too little attention. It is one that must be worked out by the societies so I will not dwell on it further.

Universities can and must contribute heavily. They have an educational atmosphere which is difficult to achieve in industry. In this atmosphere, they can foster the young man's realization that he should continue his education after graduation. They can also make it clear that his further education has the full backing and support of industry, and that industry is interested in his training program even before he graduates. This teaming of schools and industry is good because it brings them closer together. This closeness promotes a much better understanding of the aims and objectives of both groups. So I say, our program is good for the man, for industry, for the schools, and for the societies.

SHORTAGE OF ENGINEERS

One more point—the shortage of engineers. When we study the reasons for this shortage we find that we are not always providing the right kind of guidance and training in our high schools. In many cases, we are not encouraging the right high school graduates to continue their education in the field of engineering.

Here is an interesting side light on this point. After an analysis of engineering work in our company, we decided to use more technicians—helpers and assistants for our graduate engineers. This provides an opportunity for these technicians to develop further along technical lines. But we found there were not enough technicians available. So we organized a technicians course at the University of Pittsburgh. Successful completion of a certain number of semester hours would entitle the student to a certificate. Continuation for additional semester hours would eventually lead to a bachelor's degree. In the first course there were 179 applications in the Pittsburgh area. Analysis showed that of this number, 40 graduated high in their high school class. But these men had not taken the necessary mathematics and science courses for engineering training and had to be eliminated. Of the 139 remaining, 38 were in the top 20 per cent of their graduating class. With this example, I am trying to make two points.

The first point is that we are not getting all the capable people to take the necessary courses for continued study in engineering. The second point is that with the process now in existence, we are missing a lot of young folks fully capable of continuing their education in engineering. To solve this problem, some of the other committees of ECPD face a real challenge. I know they are presently driving very hard toward a solution.

I feel that the present shortage of engineers will be greatly alleviated if we can follow through on some of the things we have talked about and if we can make engineering sufficiently interesting. We are aware that, today, we are in a competitive race in the training of technical men. Some of you have seen Dr. Trytten's analysis of the engineering training programs now underway in Russia. They are graduating around 30,000 students annually with the equivalent of a 5-year course in engineering. These are backed up by some 60,000 technicians a year. After a number of years of this program, Russia has almost as many engineers as we have, and the rate of production is far greater than ours. This is a serious challenge to our national security.

Another sobering point—Russia has about $3\frac{1}{2}$ times our number of trained teachers in schools preparing these students for the universities. This is about $3\frac{1}{2}$ times the number that they had 5 years ago. Thus, the pipe lines are filled with teachers to keep the program moving ahead at a rapid rate.

Looking at our own situation, if our ECPD training program is good, we ought to expand it. These gentlemen, here in Cincinnati, have put a great deal of time and effort into this initial venture and they are to be congratulated. What we need now are many similar organizations throughout the country. In our early studies, we found that there are at least 50 cities that could use some sort of Cincinnati plan. With Cincinnati rolling at the end of 2 years, we hope to get four more underway. I believe four cities were mentioned in the report and some of the people are here today. For instance, Mr. George Porter is laying plans for carrying on in the Detroit area. Atlanta, Ga., Tulsa, Okla., and Hamilton, Ont., Canada, are also on the books. If then, in 2 years, we can get eight more started, this ball will really begin to roll.

We must first, however, be sold that our plan is good and that it can be carried forward. Let me go back to our basic objective. We are not striving for better buildings, or better planes, or better roads, or better electrical plants. We are striving for better people. The mere existence of better people will cause many of our other problems to disappear. We are trying to build people, big people who will cast their shadow of contribution on the advancement of society. For after all, these contributions are the sum total of the estate which we create and pass on to our children and our grandchildren. We have witnessed the beginning of this building program here in Cincinnati. To Mr. Fields, Mr. Wandmacher, and others, my sincere congratulations.

Employers, Ethics, and Novice Engineers

C. J. FREUND

Among engineers, their professional status is one of today's live questions. That question is frequently dismissed with a statement that each engineer must improve his individual status by acting and living in a professional manner—that only thus will the status of the profession as a whole be improved.

Some observations of Dean Freund, presented in this brief and thought-provoking article, point out that the above is not the whole story; that most engineers are employees; that their employers can make a real contribution to improving the status of the profession; and that such a contribution would be in the enlightened self-interest of such employers.

I commend Dean Freund's article to the thoughtful consideration of the membership of the Institute.

G. D. Edwards, Fellow AIEE

A DEAN of engineering earns his living by doing a number of things. One of these things is to listen patiently and sympathetically whenever an alumnus, especially a recent graduate, feels like weeping on his shoulder.

Not long ago I was doing just that in my office with a young engineer 2 years out of college. He had a good job with one of our Detroit automobile manufacturing companies, and so far as I could see he was making good progress. But he was restless and dissatisfied, and he was thinking seriously of resigning and looking for work elsewhere.

This interview had a familiar ring to it. In differing words I had heard the same story time and again, and I can only conclude that many of our engineering graduates are, to a degree, unhappy and discontented.

A COMPARISON

I COULD not avoid comparing this recent graduate with a young physician of my acquaintance who is an interne in a hospital near my home.

The young physician studied 8 years following high-school; the young engineer, 4 years. The physician spent about $10,000 in tuition and fees,—or his parents did; the engineer about $2,500.

The physician has impossible working hours,—he is on call day and night. The engineer works an easy 40 hours per week. The physician is married but lives at the hospital; he gets his meals there, although he has an occasional day off. The engineer lives pleasantly with his wife and small son in a 5-room apartment.

The physician is paid $1,200 per year and his keep. The engineer was employed at $4,600 per year immediately following his graduation, and he receives more than that now. The physician is contented with his rugged and meager assignment. The engineer is sitting on top of the world and is dissatisfied.

Obviously, the young interne has something which the engineer does not have. The engineer has an immense advantage over the interne in every respect except for that something. That something makes the young interne happy with his lot, while the engineer is clearly unhappy.

I knew both young men very well. I have studied the attitudes and mode of life of each, and I have just about made up my mind that I know the secret of the peace which the interne has in his soul.

PROFESSIONAL STANDING

THE interne is a member of a great profession. He is proud of it and happy about it. The engineer may be looked upon as a professional man some day, but he is not sure. At the moment he certainly does not think much of his profession or about it.

The interne is respected. He enjoys the strictly professional privileges of the oldest surgeon on the staff. He has the title of doctor, and he is so addressed by the entire staff of the hospital. He has authority over nurses, attendants, and other employees—many of them twice his age. Patients can't distinguish between him and the younger men on the regular medical staff. Only senior physicians and surgeons may openly question his medical judgment.

The engineer, on the other hand, is just another employee—no different from thousands of toolmakers, assemblymen, pay-roll clerks, draftsmen, and the like. He has authority over nobody. He is a college-trained engineer, but nobody knows it and nobody cares.

THE ENGINEERING EMPLOYERS

NOW what can the employers of engineers do about all of this, and what, if anything, should they do? A great deal, it seems to me.

Many employers of engineers are worried about a union known as Engineers and Scientists of America, which is currently attempting to enroll employed engineers. Other unions have tried this but none has achieved more than an ambitious start. But this union might succeed, and few employers want their engineering decisions colored by union and other points of view.

This brings us to the real core of the matter. In my view, employers will have no union trouble with their engineers if they give real recognition and encouragement to the professional character and standing of those engineers.

Employers do recognize technical ability and engineering

Slightly condensed text of an address presented before the American Society for Engineering Education at the University of Illinois, Urbana, Ill., June 1954.

C. J. Freund is dean of engineering at the University of Detroit, Detroit, Mich. This is the first of a series of brief articles planned by the Institute's Committee On Code Of Principles Of Professional Conduct to encourage the thinking of the Institute membership with respect to professional and ethical matters. Personnel of the Committee are: P. L. Alger, Chairman, R. E. Argersinger, M. S. Coover, W. C. DuVall, G. D. Edwards, L. G. Gitzendanner, A. H. Kidder, W. J. Morrill, and E. W. Seeger.

competence of course, but those are not the sum total of professional standing. High honor and integrity are equally essential, and it seems to me that employers of engineers ought to be as much concerned about the ethical standards of their engineering employees as they are concerned about technical education and ability.

By ethical standards, I mean the ethical codes of the engineering profession and not any special policies or regulations of any particular corporate employer. These ethical codes are attempts to embody in words the accepted concepts of high honor and integrity in the life and work of engineers as professional men.

It would be interesting to take a census of the thousands of engineering graduates interviewed by prospective employers this year, and to determine whether any graduate was asked by an interviewer what he knew about the code of ethics of any one of the professional engineering societies. I will venture to say that no such graduate would be found.

When engineering employers insist that engineers shall know their ethics, just as they now insist that engineers shall be technically competent, they will have gone a long way toward giving engineers professional standing. Not until then will engineers in the employ of corporations begin to enjoy the professional standing of physicians and lawyers. Not until then will the engineering employee begin to sense that peace of soul of the young hospital interne.

Once their engineers have really acquired professional standing, and once they really recognize that fact, employers can safely discard the countless rules and regulations of the familiar employees' handbook so far as those engineers are concerned. They need only explain to them a few basic company policies, and they can rely safely thereafter upon their honor and integrity as professional people. In return for the personal privileges which go with real professional status, such employers will have no union problem with their engineering staff—and in fact, few personnel problems of any kind. Unions do not try to organize people who are clearly professional. Physicians, lawyers, and clergymen are not found in the American Federation of Labor or the Congress of Industrial Organizations.

NO MISUNDERSTANDING

I SHOULD explain emphatically at this point that I am not opposed to decently and legally managed labor unions in their proper function. But I am unalterably opposed to such unions in the professions—in medicine, in law, in the ministry—and in professional engineering.

CONCLUSION

HAVING acknowledged this problem of engineering ethics, we must recognize there are two sides to it. If the employers of engineers are to make a beginning on their part of this sort of a philosophy, if they are really to begin to look for young engineers who know their ethics, it is going to be up to colleges and engineering schools to teach ethics.

In the past, engineering students have been taught reasonable competence in technology, but they have heard precious little about engineering ethics. I respectfully suggest that it is high time for engineering education to mend its ways.

Twelve-Story-High Boiler Guarded from California Quakes

The newest and largest steam electric power generating unit of the Southern California Edison Company, including the largest boiler of its type in service west of the Mississippi River, has recently gone into commercial operation at Redondo Steam Station, Redondo Beach, Calif. This newest addition, Unit 5, adds 160,000-kw capacity to the system, which brings the combined Redondo Steam Station to 448,000-kw capacity.

The earlier station units were designed primarily for operation throughout a wide and variable load range; the new unit was designed specifically for continuous full-load operation at a maximum efficiency. In fulfilling this basic requirement of high efficiency each kilowatt-hour is produced with 1/2 pound of oil. This is possible primarily through high-cycle pressures and temperatures, 1,800 pounds per square inch, 1,000 F and reheat to 1,000 F.

Relative to the high-cycle pressure, the new boiler towers as high as a 12-story building. This height is a particular problem in earthquake country, such as Southern California. Special attention, therefore, was given to resistance to horizontal forces within a structure such as develop during quakes. As a result, the supporting steel for the boiler is exceptionally rugged.

Aircraft Windshields Heated with Conductive Films

JOHN WARD
ASSOCIATE MEMBER AIEE

PREVENTING the formation of ice on outside surfaces of aircraft windshields is a serious problem to the designers of all-weather aircraft. The development of a transparent conductive film* which can be applied to a glass surface promises to offer an ultimate solution to this problem. By means of the transparent conductive film, electric energy can be dissipated near the windshield surface resulting in excellent de-icing characteristics.

The first installations of electrically heated windshields encountered serious structural and electrical difficulties. A development program was undertaken to try to find the causes of service troubles and develop suitable remedies.

The electrically heated windshield is usually of laminated construction having an inner and outer pane with a plastic interlayer. The inner pane is the structural member and is designed to carry the load of pressurization. The vinyl interlayer imparts a shatterproof characteristic, and also serves to support pressure loads when the inner pane fails. The transparent conductive film is applied to the inner surface of the outer pane next to the vinyl interlayer.

The transparent conductive film of stannic oxide is about 20 millionths of an inch thick and is as hard as the glass itself. It is not affected by temperatures within a range of −75 F to +700 F. For aircraft applications a nominal resistivity of 70 or 120 ohms is used per square. Electric connections to the film are made by means of fired-on metallic bus bars located along opposite edges of the pane.

Because of nonrectangular windshield shapes and inadequate control of film resistivities, the heating of the windshields was not uniform. Furthermore, no method of either measuring or limiting this variation was available. The points or areas on the windshields where a knowledge of the power dissipation is necessary are the hot spot, the control point (location of a temperature, sensing element), and the average power over the entire heated area. "Power constants" or ratios of the power in these areas were used to specify desired heating characteristics. Temperature rises above ambient at two points will always be in the same ratio as the power dissipations. A windshield with perfectly uniform heating would have "power constants" equal to unity.

The power dissipated at a point on the conductive film is found by means of thermocouple measurements. It was found that the temperature difference between points on opposite surfaces of a pane of glass, heated by means of the film, was related to the power dissipated at that point by the following formula

$$\frac{\text{Watts}}{FT^2} = \frac{(\Delta T \text{ in deg F})}{K\ (\text{glass thickness in inches})}$$

where

ΔT = temperature difference in deg F

K = constant depending upon the thermal resistivity of the glass. This constant was found to be about 0.24

This method of power measurement at points on the conductive film is used to determine that windshield power constants are within specified limits.

Simulation of the most severe flight condition in the laboratory allowed problems of a structural nature to be studied. These tests subjected windshields to maximum pressure load, maximum power input, maximum operating temperature, and minimum outside air temperature. Design improvements were also evaluated by subjecting windshields to these operational tests.

As a result of the laboratory testing program and development work by the windshield manufacturers the following improvements in the windshields have been made:

1. Methods of applying bus bars (electrodes) were developed which eliminated failures at the connection to the film.
2. The glass temper, bending modulus of rupture, obtainable in a conductively coated panel has been increased through the improvement of manufacturing methods. The ability of the windshields to withstand pressure and thermal stresses was thereby improved.
3. Methods of controlling film resistivity were developed. More uniform heating has resulted.
4. Quality control and inspection methods were improved to eliminate glass and conductive film irregularities.
5. Methods of preventing glass edge chipping at low temperature were developed.

As a result of the laboratory testing program, operating and installation procedures were also evolved, which have materially improved windshield service life.

Aircraft windshields heated by means of transparent conductive films have been successfully used on a number of aircraft during the past several years, 1950 to date. Reports on these windshields have indicated that their performance has been most satisfactory. It is believed that the improvements noted above have made possible the successful application of this new product and have reduced failure rates to the point where they are no longer a major economic factor. The development of windshields heated by means of transparent conductive films has given the aircraft manufacturer an important tool which can be used to improve the safety of modern aircraft.

* Electrically heated windshields are manufactured by the Pittsburgh Plate Glass Company under the trade name *Nesa*, and by the Libbey Owens Ford Glass Company under the trade name *Electrapane*.

Digest of paper 54-525, "Aircraft Windshields Heated by Means of Transparent Conductive Film," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Committee on Technical Operations for presentation at the Fall General Meeting, Chicago, Ill., October 11–15, 1954. Published in AIEE *Transactions*, vol. 73, pt. II, 1954 (Jan. 1955 section) pp. 408–16.

John Ward is with the Boeing Airplane Company, Seattle, Wash.

Implementation of a Research Program for the Electrical Utility Industry

J. E. HOBSON W. A. LEWIS M. S. OLDACRE

The electrical utility industry has a need for more extensive research activities to investigate basic problems and to provide for its long-range needs. Such a program should attract the interest of engineering students, who oftentimes believe that the power industry offers little opportunity for creativeness.

At the New York meeting of the AIEE in January 1954, two of the authors presented a paper[1] which stressed the needs of the electrical utility industry for an expanded program of research. This theme was expanded and supplemented in a similar paper presented before the American Power Conference.[2]

The objective of this article is to summarize the comments received on the first two and to make further suggestions for a research program for the electrical utility industry.

COMMENTS ON PREVIOUS PAPERS

The first papers were followed up by many discussions with utility executives and engineers, college faculty members and students, financiers, economists, and leaders of other industries. An extremely wide range of views was found. There was majority, but decidedly not unanimous, agreement that more extensive research programs are desirable—programs which will investigate basic problems of the industry and provide for its long-range needs. Some utility executives were inclined to leave the job of research and development entirely to equipment manufacturers, being satisfied with whatever technical progress is offered to them. Some believed that the role of the utility companies in research should be confined to encouraging and co-operating with the manufacturers by proving and testing manufacturers' research results. Others expressed themselves as being distressed by the duplication of efforts, facilities, and investments that are necessary when similar and parallel research and development programs are carried on independently by several manufacturers.

It was frequently pointed out that there is a very serious lack of knowledge about how much and what kind of research is now being performed by the utilities, and that a carefully conducted survey of present research activities would be very beneficial in evaluating the situation as it exists today. Many investigations that are really of a research character are handled as incidentals of system operation or new construction, and thus are not identified as part of the over-all research effort.

The members of college faculties with whom these problems have been discussed were in unanimous agreement that additional research and technical effort directed toward the problems of the utility industry would attract the increased interest of engineering students, who are now inclined to believe that the power industry offers little opportunity to employees of imaginative and creative minds.

Some of the financiers and bankers who were contacted pointed out that an active and aggressive research program is now considered one of the essential factors in selecting companies for investment, and that the electrical utility industry would perhaps more easily attract capital needed for anticipated expansions, if it were more active in its research efforts. The record of the utility industry in this regard has, of course, been outstanding.

The authors were struck by two significant impressions: the wide divergence of opinion on research policies expressed by the executives of utility companies; and the

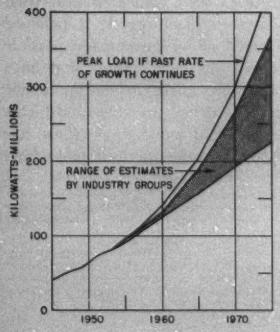


Fig. 1. Peak load, 1945–1975, for the electrical power industry in the United States

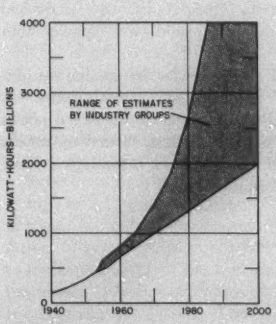


Fig. 2. Output, 1940–2000, for the electrical power industry in the United States

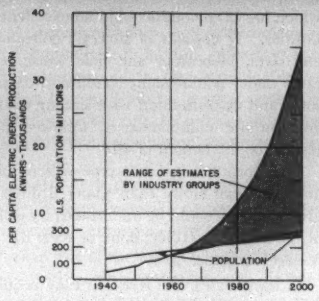


Fig. 3. Production per capita; needs of the electrical power industry customers in the United States

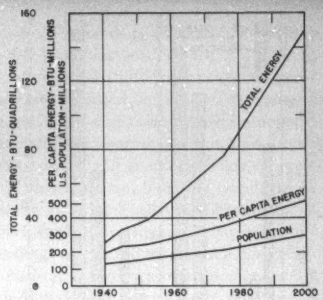


Fig. 4. Input to the energy system of the United States from mineral fuels and hydroelectric power, 1940–2000

inescapable feeling that too many utility engineers, as a result of their necessary concentration on everyday problems, do not have a clear understanding of what scientific research actually is, or of what research might be able to do to benefit the industry.

AREAS OF RESEARCH FOR THE UTILITY INDUSTRY

MANY of the problems of particular significance to the electrical utility industry may be classified under the following areas of research:

Long-range planning for system development.
Application engineering research.
Research in operation of utility systems.
Apparatus development.
Research for the future.

Various methods for conducting research in these areas will be discussed in an attempt to suggest some measures that appear to be appropriate.

Long-Range Planning for System Development. The utility industry in the past has been noted for long-range planning in providing for its continued growth. Present methods have been satisfactory, but tremendous post-war growth and rapid industrial changes indicate that new techniques of planning for the future are needed, and that simple extrapolations of load curves do not give a true picture of power requirements for more than a few years ahead.

Forecasts of load growth, published by many different organizations, show a disturbing diversity of opinion. Fig. 1 shows the range of estimates of peak load to 1975, as an extension of the load curve since 1945. Some estimates are based on the growth of the recent past with a doubling of load about every 10 years or less; that will give a peak load of over 400-million kw in 1975. Other estimates apply correction factors to those estimates and arrive at forecasts nearer 225-million kw.

More penetrating studies must be made to analyze the factors that affect demand upon the utility industry. These will include detailed consideration of expected population growth and migration; of the agricultural, industrial, residential, and transportation needs of an area; and considerations of how the energy needs may best be met. Careful consideration of these and other basic elements will provide a much sounder basis for making long-range plans for system growth, not only for the design and building of a particular power station, but for planning 10, 15, or more years ahead.

Of equal or greater interest is the probable total energy output of the electric systems and the production in kilowatt-hours per capita. These are shown in Figs. 2 and 3. Even the most pessimistic estimates for 1975 show more than twice the present figures. This increased per capita use should satisfy the dreams of the commercial departments, but the engineering departments will need to plan far ahead to solve the problems of greatly increased generation, transmission, and distribution.

Of great importance in the future will be the changing fuel-supply picture, not only of individual utilities, but for the country as a whole. Revisions currently being made by different authorities in the estimates of fuel resources make it difficult to predict how long they will be adequate for all needs at anywhere near present-day costs. One of the most penetrating of recent studies on this subject was reported by C. C. Furnas before the American Chemical Society in September, 1954. His analysis of the information presented in "Energy in the Future" by Palmer Putnam showed that, with the given expected population growth and increased energy use, the United States and the world face a shortage of conventional energy sources that will become acute in 20 to 50 years. This eventuality will have serious effects on factors of great importance to the electrical utilities and must be carefully considered in present planning.

The total demand for energy in this country does not increase as fast as the demand for electric power, but is expected to about double by 1975 and quadruple by 2000. An indication of what may be expected in total energy demands and population growth is shown in Fig. 4, while the amount of energy available from various sources at costs comparable to present day costs is shown in Fig. 5. It may be anticipated that new or more expensive energy sources will be needed in the next few decades.

The peak rate of petroleum and natural-gas production in the United States will probably occur in about 10 years. When new discoveries are no longer able to keep ahead of

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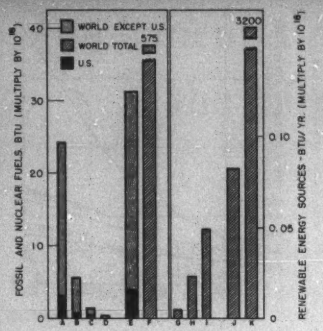

Fig. 5. Where the energy may come from; nonrenewable or capital sources and renewable or income sources

A = Coal, B = Oil and gas, C = Oil shale, D = Tar sands, E = Total fossil fuels, F = World total—nuclear fuels, G = Water power, H = Wood, farm waste, and miscellaneous, I = Effective recovery from solar heat collectors, J = Total renewable or income energy sources, K = Total solar energy falling on earth's surface

new demands, the available supplies will have to be conserved and limited to the more exacting needs to which their application is particularly suited, such as liquid fuel for automobiles and airplanes, and gas for residential heating.

The remaining needs will have to be satisfied by using lower grades of petroleum residues and by the increased and more efficient use of coal, lignite, and other solid fossil fuels, or by nuclear and solar energy. A possible means to release oil for power-station fuel is the development of batteries or other storage devices for economically using electric energy in operation of vehicles.

The weakest part of the present position is a lack of fundamental knowledge of combustion processes, and that weakness can be overcome only by research of a basic or fundamental nature.

Detailed research and economic studies of load demand and fuel use in a given area are local problems peculiar to the company or companies in the area, but the basic problems of fuel availability and fuel processing are of such magnitude and over-all importance that they could be undertaken by the energy-using industries as a whole, possibly through an industry association or other organization which would have such research as one of its major objectives. Support for industry-wide work of this type may properly come not only from the utilities, but from the suppliers of fuel and the manufacturers of equipment.

Application Engineering Research. Equipment supplied by the manufacturers makes use of the best information available to the manufacturers concerning the requirements of operation. It is well known, however, that after machinery is put into service, difficulties usually develop that were not anticipated. Improved methods of determining and evaluating important characteristics are required. Investigations to improve knowledge of operating conditions and effects of environment can minimize these difficulties, reduce maintenance expense, and improve the design of subsequent equipment. Such studies are especially important when the equipment is so large or complex that it must be assembled at its final location without trial operation under controlled factory conditions. Investigations of this type may properly be called application engineering research which has been conducted in an excellent manner by many utilities. It consists of surveys, collection of information and data, laboratory and field work, operation of apparatus under actual plant conditions, careful analysis of results, and co-ordination with similar work by other utilities and by the manufacturers, followed by distribution of results for the benefit of all.

Some problems of this type will require more detailed and extensive study than many utilities are prepared to give, but they could be undertaken by technical committees of the industry, either alone or with the aid of colleges or research organizations.

In some cases, the research may require the services of scientists or engineers in special fields not normally employed by utility companies. It may be necessary to obtain information or to develop materials not now available. Thus, special laboratories and staffs may be needed. A few examples of areas where improvements are essential include new materials for very high and very low temperatures; materials for use in nuclear power applications; insulating materials suitable for the extra-high-voltage systems that will undoubtedly be needed in the future.

Discussion with utility executives and engineers has shown that much more work of this character has been done by certain leading utilities than is generally appreciated. It is also recognized that the manufacturers are making significant contributions in this area and will continue to do so. However, it is the authors' feeling that more active participation by the utilities would produce important apparatus improvements that could result in over-all economy for the industry.

Research in Operation of Utility Systems. Much has been done in investigations regarding: the stability and control of interconnected systems; the proper protection of systems against disturbances, such as lightning; and the protection of system operation against the effects of sudden loss of generation. However, there is a growing awareness that, with the continued growth and expansion of utility systems, research on the problems of system operation is necessary, and that many of these problems pose a real challenge for further improvement.

Not only are the ordinary operating problems of interconnected systems becoming more intricate, but the requirements for operating the entire system at maximum economy become so complex that conventional methods of calculation are becoming inadequate in many cases.

New computing techniques are required for the quick and accurate determination of operating conditions for minimum system losses, and for the allocation of those losses to particular generating stations. There is, as yet, no clear understanding of the principles which will permit the ready determination of the most economic use of water power in systems which have substantial amounts of both hydroelectric and fuel power supply. Because of the increasing complications of power systems, the trend toward automatic operation of the systems for maximum economy is clearly evident.

Only a few utilities conduct research on the effects of weather on the operation of the utility system; this subject

could be the basis of discussion to show how meteorological research could pay big dividends in guiding operation and loading of the utility system and in preparing for emergencies. The weather bureau performs a good service in providing the basic information, but the utilities should be better prepared to apply that information to its own particular conditions.

Another problem seems to be the lack of a clear-cut basis for determining the proper financial arrangements for power interchange between interconnected systems.

In the administrative side of the utility business, the best utilization of business and computing machines in the handling of customer billing, inventory control, and other data processing has not been fully realized and further research is justified. It seems evident that a much better understanding of the economics of replacing obsolescent equipment is desirable. In the establishment of rates, there is not yet an adequate and accepted basis for allocating the cost of service to various kinds of loads, thereby fully justifying rate differences for separate classes of customers.

It would seem that better answers to these and similar problems would result in enormous savings, because of the large volume of the utility business, and would, therefore, justify extensive research effort by both utilities and manufacturers. Manufacturers of large apparatus have contributed importantly to the solution of system problems when the results affected the characteristics of apparatus or machines. Similarly, manufacturers of computing and business machines may be expected to participate extensively in research leading to the development of the most effective types of such machines for utility use.

Because of the complications of mathematical and computing problems involved in many of these studies, it would seem that research organizations and colleges, which have groups of specialized personnel, could be used appropriately, effectively, and with mutual advantage.

Apparatus Development. Many utility executives have stoutly maintained that utility companies should have no part of apparatus development, but should use what has been offered by the manufacturers at a price which includes the cost of research and development. It is the belief of the authors that the primary responsibility of the utilities in apparatus development is to make sure that the job is properly done for the best interest of the utilities. Experience in other industries has frequently shown that research programs are less effective if all interested parties do not participate actively in the planning of the work, and in the analysis and evaluation of the results. There is no reason to believe that the same is not true in the electrical utility industry. Many examples can be given where utility participation in the planning and testing of apparatus in the development stage has been extremely beneficial.

When the manufacturers are not ready to undertake or carry forward desirable developments, the utilities may very properly initiate and conduct such projects alone, at least until they secure the co-operation of the manufacturers. In short, apparatus development must be a "two-way street" in which the users have an important function that is not always fully appreciated.

Research for the Future. The kinds of research and development discussed in the preceding sections are of direct and immediate interest to electrical utility companies, but in several instances it has been pointed out that all the essential information is not available, and progress will be impeded if new and more penetrating information and data are not developed, in both technical and economic fields.

There are several areas of knowledge on which the industry rests, where the underlying scientific phenomena are unknown and where further investigation may point to a broader understanding of the physical phenomena and lead to new and entirely unexpected developments. Experience of other industries indicates that effective research on such problems may open up entirely new possibilities that will have tremendous advantages to the industry. Although the need is not so apparent, the returns may be greater than for research directed within narrower limits.

The important feature that these areas of research (for essential information or for underlying phenomena) have in common is the necessity for a careful scientific approach, in which the abilities and skills of scientists such as chemists, physicists, metallurgists, and mathematicians, as well as economists and, perhaps, even biologists and psychologists, may be needed to make the work effective.

Several research areas for essential information in which the results may be immediately applied have already been suggested. Other basic problems of equal importance to the industry could be named. Areas of research where the industry is in need of broader fundamental knowledge have been mentioned in previous papers.[1,2] These included: a comprehensive study of insulating materials in an effort to better understand their behavior, and to prepare the way for the development of new and more effective insulating materials; a more precise understanding of the factors affecting corona; a better understanding of magnetism, leading to possible improvements in magnetic materials; a scientific understanding of switching; the electric arc and electric discharges in gases, liquids, and solids; studies of other methods of converting energy into electricity; investigation of possible new methods for electric energy storage, conversion, and transmission; new knowledge regarding the properties of steam at supercritical pressures and temperatures; and the possibilities for further improvements in combustion of fuels.

It is true that a few electrical utilities are already quite active in some research fields either by their own engineering, technical, or laboratory staffs, or by sponsoring work at universities or research organizations.

Particular mention may be made of the study groups engaged in the development and investigation of nuclear power possibilities. Others have already undertaken the installation of steam generators and turbines operating in the supercritical range. In most cases, these have been spectacular projects that fire the imagination and have great publicity values because of their promise of large returns. It is the belief of the authors that many of the less spectacular projects are of broad significance to the industry as a whole, and have great potentialities for improvement but are now receiving inadequate attention under present conditions.

If substantial improvement is to be made in the conduct of desirable research, a suitable mechanism must be established. In the preceding sections, several different methods for conducting research were discussed, and some are in actual use. The manufacturers of apparatus, as well as others outside of the power industry, have conducted much of the basic research but the amount of such research that can be financed on the prospect of early return in apparatus improvements or can be justified from the standpoint of public relations, is definitely limited, and the authors believe that the existing methods of financing are insufficient.

Most of the electrical industry research projects have been of definitely limited duration with the expectation that they will be terminated as soon as specified goals have been reached. From a long range point of view the benefits of continuity of effort and thinking are lost although their value has been demonstrated in other industries, (the chemical industry, for example) many times over.

With these thoughts in mind, the importance of a cohesive group of scientists and engineers, including several areas of training and experience, assigned full time to the study of the industry-wide research problems, becomes evident. It should be the function of such a group not only to evaluate continuously the research program of the utilities but also to examine and make recommendations for the research conducted by the manufacturers, and by colleges and research organizations whether sponsored or not, and to observe contributions from foreign countries. Its members should be ever seeking new ideas and the adaptation of old ideas to new situations. Such a group would form the liaison between the application engineers of the industry and the fundamental scientists who would be most effective in carrying on the more fundamental work. This co-ordinating group could be in a position to participate in the placing of contracts for sponsored research, either directly, on behalf of an industry association, or in the guidance of individual utilities in the sponsorship of work in which the company was particularly interested. The essential belief of the authors is that the implementation of basic research through temporary committees of engineers who have primary interests in other directions will not produce the most effective results.

It has been tacitly assumed in the foregoing discussion that any such co-ordinating research group would have to serve the entire industry, and would most surely have to be supported by some form of industry association, either of the utilities alone, or of the utilities and manufacturers together. Experience in other industries and in the conduct of war research has shown that research scientists, particularly in experimental fields, are most productive if they have at their disposal suitable laboratory facilities for the conduct of some phases of the work, to try out new ideas in early stages, and to check questionable parts of the work done by others, even if all of the work is not done under their direct and immediate supervision.

It was reasoning along these lines which led the authors to suggest in the previous papers the desirability of an industry-supported laboratory, in which the basic and fundamental research activities could be conducted. A research budget in the order of one-tenth of one per cent of the gross income of the electrical utility industry, was suggested as being appropriate after an early developmental period.

GENERAL COMMENTS AND SUMMARY

In the preceding sections several different phases of the research program appropriate for the electrical utility industry have been discussed, and several methods for accomplishing the necessary research have been outlined. It is believed that no single method or form of organization would be fully effective or most satisfactory for the conduct of the various classes of research to the exclusion of other methods. The needs are many, and the type of problems at hand suggest the possible method of approach that may be most appropriate in each case.

The research subjects suggested as examples in the discussion have been more or less arbitrarily assigned to the different phases of the program but they might have served equally well as examples of some other class of activity.

However, consideration of all the different research activities needed seems to show that co-operative action among the utility companies, with the manufacturers of equipment, with the suppliers of fuel, and in special cases even with other groups, is essential if a full measure of success is to be reached.

The long-term objective of any research program is, of course, to make possible improvements in the delivery of electric energy at lower cost, recognizing fully that the electrical utility industry deserves to prosper only if it can deliver energy more economically in a form which can be more conveniently utilized than competitive forms of energy delivery. Therefore, all research activity, both economic and scientific, must have continually in mind economic considerations, in the evaluation of improvement, and in the consideration of alternatives. When research is conducted through short-term projects, with a specific end in view, it becomes exceedingly difficult to give proper consideration to all the background economic factors. To give effective consideration to these aspects, it is essential that there be continuity of planning, guidance, and supervision of the over-all research program.

The reaction of college faculties to the ideas and suggestions for a broader and more extensive research and development program has been expressed earlier in the article. The authors have previously indicated their belief that an expanded research program for the electrical utilities and a change of attitude in the utility companies regarding the place of research in their work would have a salutary effect on the interest that college graduates would have in the utility industry. Under present competitive conditions it is not sufficient simply to explain to college faculties and students that the utilities have challenging problems, but this situation must be illustrated by action and results if the better men are to be attracted into the industry in adequate numbers to meet the growing personnel needs. The establishment and sponsorship of appropriate research projects in college laboratories, and the active participation of utility engineers and co-ordinating scientific groups in the planning and conduct of these research projects can well be the means of restoring or creating interest in the power field to the college staffs and college students.

Otherwise, the gradual drift in emphasis in electrical engineering education will continue toward the electronic and communication fields, to the point where any special emphasis on the needs of the power industry will be as unheard of as specialization in electronics and radio was 30 years ago.

In comparing the electrical utility industry with other industries, it appears remarkable that the industry has been able to avoid the establishment of some form of central research organization when so many other industries, with less reliance on technical background, have such organizations in existence. In a recent report, J. Judkins, Chief, Trade Association Division, of the United States Department of Commerce has pointed out that nearly 50 trade associations have well staffed laboratories, for the conduct of technical research. He further states that roughly 300 associations have invested their funds in: scholarships at engineering colleges; fellowships, etc., at research institutes or the National Bureau of Standards; co-operative research in university laboratories; or privately owned commercial testing laboratories for various forms of research activities. Although the electrical utilities, as regulated monopolies subject to government control, do not have the same competitive urge as manufacturers, the need for continued improvement in their service to the public is just as great, and methods which have been found extremely effective in other industries should not be passed over by the electrical industry without convincing proof that direct research activity would not more than justify its costs. Any doubts that the electrical utilities are in a competitive field, in their primary function as suppliers of energy, are dispelled when attention is called to the importance given to any means that will result in lower investment cost per kw capacity of equipment, or will reduce the cost of operation and maintenance. The competition between electrical utility energy delivery and other forms of energy delivery, and the competition between various areas of the country for industrial growth and the location of new plants, makes clear that the industry is in truth subject to all of the forces of competition, and every means which will result in better service at lower over-all cost must be utilized for best results. Any private utility that does not heed this premise becomes a vulnerable target for public power, whether municipal, utility district, or federal.

The experience of many industries has proved conclusively that long-term research, carefully and intelligently conducted, will frequently pay tremendous dividends. However, important projects can only be brought to fruition if carried on uninterruptedly, with continuous re-evaluation and study, and with unflagging faith in the ultimate result. Short-term projects, with limited goals, have their value, but the biggest returns can be expected from the more penetrating studies of the bigger and more lasting problems. Visionary dreams still have their place in industrial development and may be the very ideas that, if carefully nurtured, produce new trends and revolutionary developments in human progress. The authors cannot accept the belief that the electrical utility industry is so mature that it has no need for entirely new methods, but only for improvements in existing methods of doing things. With the depletion of existing fuel resources becoming dangerously imminent, with nuclear power upon the threshold, and with the challenge of solar energy as the ultimate means of meeting man's need for energy when other sources are either exhausted or uneconomical, the pioneering spirit which is shown by some of the utilities must spread throughout the industry, which in the short space of 75 years, moved an item of curiosity to one of the greatest essentials of everyday life. The tool of the industrial pioneer today is scientific and economic research, and the electrical utility industry must find the means to utilize its full share of research potentialities, to insure its continued growth and success in the future.

REFERENCES

1. Research for and by the Electric Utility Industry, **J. E. Hobson, W. A. Lewis,** *Electrical Engineering*, vol. 73, June 1954, pp. 516-21.

2. Research and the Electric Power Industry, **J. E. Hobson, W. A. Lewis.** *Proceedings*, American Power Conference, Illinois Institute of Technology, Chicago, Ill., 1954, pp. 6-17.

Steel "Face" Is Top-Half of Turbine Shell

Steel "face" is actually top-half of turbine high-pressure shell. Mammoth unit is being machined on 18-foot boring mill at the General Electric Company's large steam turbine-generator factory at Schenectady, N. Y.

The mouth-like opening admits initial high-pressure high-temperature steam from the boiler into the turbine. The steam is then returned to the boiler for reheating and is readmitted into the turbine by way of the two eye-like openings.

The "face" surfaces have been whitened to facilitate laying out locations for subsequent machining and drilling operations.

The giant shell, which is part of a 100,000-kw power-maker, weighs 60,000 pounds and is more than 11 feet long.

Educating Electrical Engineers to Exploit Science

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Are the future electrical engineers being trained broadly enough in the sciences? This question has been given serious study at the Massachusetts Institute of Technology, with the result that major changes have been made in the undergraduate electrical curriculum, so as to better equip the students with technical substance and professional vision.

THE insatiable urge of man for greater command over his environment continues to expand the industrial system. Industry is being called upon to increase both quantity and quality of its product. As science opens up new frontiers, industry is also being called upon to establish wholly new products.

The pace at which technology is asked to achieve these events continues to quicken. The time interval between the birth of a new discovery in science and its exploitation in industry and commerce continues to diminish. Of the various contributory factors, among the most dominant are, first, the expanding nature of science and, second, the versatility and flexibility of scientists and engineers whose roots are deep in the realm of science. Throughout all industry the boundaries between the traditional categories of engineering, such as electrical, mechanical, metallurgical, and so forth, are crumbling as machines and machine systems of greater capability and complexity must be created and kept running.

The engineer who is resourceful in science, who can upgrade the implements of his trade as science advances, and especially the engineer who can couple sound judgment and keen intuition with his exploitation of science, is a precious member of society. But the supply of such men is inadequate in spite of the best efforts of engineering educators. It becomes pertinent, therefore, to pose the question:

Should the future electrical engineers be educated first as electrical scientists and subsequently as electrical engineers?

There are several pedagogical reasons that support the question. One is that science clearly dominates modern engineering. Another is that up to the turn of the century, many electrical engineering departments were formed around a body of science that had split off from physics. Their technical activities were focused mainly at the engineering of electricity and magnetism. A third is that there has been a veering away from a training that would make engineers continually useful as science advances, along with a preoccupation with the training of men to be useful to specific industries immediately upon graduation.

There are many signs that future engineers are not being trained broadly in the sciences. This is an issue in the recent interim report of the Committee on Evaluation of Engineering Education of the American Society of Engineering Education.[1] The question has been given serious study by the faculty of the Department of Electrical Engineering at the Massachusetts Institute of Technology, with the result that major changes have been introduced into the undergraduate curriculum required of all electrical majors. In order to put a discussion of the changes in the proper context, a review of the heritage and growth of engineering is in order.

THE HERITAGE OF ELECTRICAL ENGINEERING

UP to about the turn of the century, the mission of most electrical engineers was to invent, devise, and manufacture a vast variety of such things as motors, generators, transformers, transmission lines, switchgear, relays; and to integrate them into great energy-processing systems or telephone-telegraph systems. Their tasks called for judgment and intuition coupled with an awareness about economic and social trends. The heritage left by these men is superb, for now the United States has the world's greatest telephone system, and the most efficient, reliable, and extensive electric power system in existence anywhere. Its power systems operate with near-perfect waveform, frequency control, and voltage regulation. However, while the power industry was maturing, science was opening up new areas of technology that attracted the interest of electrical engineers. By the late twenties or early thirties, the era of electronics had attained adolescence. As each young group of engineers expanded electronic technology in new directions, the teacher and student interest in the power area became attenuated.

Under the World War II pressures of survival, the tempo of technology was fueled by the advent of many scientist-engineer teams. Wholly new industries came into being around the fields of radar, computation, television, servomechanisms, nucleonics, and many others, and captured the interest of the best graduate engineers. In response to the demands of industry for engineers who could be immediately useful to it in these fields, engineering school curricula tended to split from the two camps—namely, power and communications—that had dominated the period between World War I and World War II, into upwards of six

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to ten camps by the turn of the midcentury. The early option structure of power and electronics was expanded in some institutions to include such categories as industrial electronics, radar, and control. New subjects were added to overcrowd the curriculum just as more lights are often added to an already overlit Christmas tree. Eventually, educators were trapped by the dilemma of unmanageable specialization. (The roster of Scientific and Technical Personnel prepared by the Engineers Joint Council of the National Science Foundation lists 31 categories of specialization under Electrical Engineering.)

The growth of options led students into the habit of typing themselves prematurely under the pretense that a curriculum with a strong vocational flavor, or patterned along the needs of an industry, would provide the motivation or vehicle for a broad basic education in the fundamentals of electrical engineering. Actually, this was a high price to pay for motivation, for it tended merely to hold captive a body of students for a specific industry and was no guarantee that they would agree to work within that industry nor that they would be offered employment in it upon graduation.

Options placed undue emphasis on learning the known art of today rather than understanding the science that would dominate the art of tomorrow. They perpetuated an academic plant that was narrow in its educational value and a deterrent to the development of broad creative thought. They were insensitive to the changing nature of science and to the fact that electrical engineers skilled in the engineering exploitation of science are not restricted to careers in those industries normally thought of as electrical. These engineers are in demand throughout all industry.

Educators traditionally say that their job is to train students to think. Equally important is the job of ascertaining clearly what students should think about. To help avoid the pitfall of thinking too narrowly about training men for the immediate job, perhaps the true role of a university needs re-emphasis.

THE ROLE OF A UNIVERSITY

No institution of higher learning fulfills its mission by merely keeping abreast of today's knowledge and by training men for the immediate practical industrial task.[2,3] On the contrary, it should continually readjust its goals and remould its environment so that both faculty and students are concerned not only with today, but also with the topics, the ideas, and the issues that will dominate the world a decade or more hence.

Every engineering school should foster a creative interdepartmental environment. It should encourage both student and faculty to think creatively outside the categories of engineering and science that have come into existence because schools, and the engineering profession itself, have traditionally organized by departments. It should guide the student toward the creative nonconformist exploitation of science to do useful things in tomorrow's world, rather than merely rework the solved problems of yesterday. It must achieve an on-campus blending of engineering, science, and the humanities. It must attack mature, sophisticated problems, for the blending cannot occur in a vacuum. This will mean that the environment will undergo constant change. The pace of the change will be dictated, first, by the rate at which science advances and, second, by the rate at which these advances are exploited at the frontiers of engineering.

THE NUCLEUS OF ELECTRICAL SCIENCE

The mission of electrical engineering education becomes clearer if one can visualize a nucleus or a conceptual model of electrical science. The blend of technical substance that forms this model must be broad enough to serve the expanding systems and nature of electrical engineering. One statement of a conceptual model is that:

All so-called electrical devices are manifestations of how a creative engineer has exploited the interactions between charge carriers, their fields, and materials.

The charge carriers are ions, electrons, and even the newcomer, the hole. The fields are static and dynamic. The materials interact with the fields by virtue of their physical properties, or magnetic domain structure. The engineer's goal in the exploitation of this conceptual model is to bring into existence an array of engineering systems to perform useful functions.

This model touches every facet of an engineer's life, whether in research, in development, in manufacture, or in business. All devices patterned after this model, when welded into systems, support two great missions of the electrical engineer: the first being to process and transmit information; and the second being to exploit energy. Fulfillment of the former mission has created such industries as radar, radio and wire telephony, television, instrumentation and measurement, electronics, computation, and controls. The lusty newcomer, automation, is its latest offspring. Fulfillment of the latter mission furnishes the means which turn the wheels of American industry and provide the basis of modern civilization. Here the dominant issue is to exploit energy for energy's sake. The fulfillment of either mission is dependent on the same hard core of science. The hardware and the systems that come into being for each mission, and their functions, undergo rapid change as science advances.

THE PRESENT STATE OF AFFAIRS

Many of the best minds in letters, science, and engineering have been challenged by the mission to process and transmit information. In an ever-increasing degree, expertness at it is becoming dependent upon an ability to make quantitative deductions from hypotheses and abstractions and to deal with matters that can be neither seen nor felt. The scope of the mission is increasing. It will play a significant role in the future development of the industrial economy and military strength.

The academic life that supports this mission is virile and creative. It is usually backed up by a well-equipped modern and flexible educational plant. On-campus research is extensive and easy to cultivate at both student and staff levels. The faculties are able and the students are attracted in large numbers.

In sharp contrast with this situation is the fact that since

the early thirties, academic work pointed toward the exploitation of energy in the field of electric power has decreased in vigor and has attracted fewer young men. The explanation for this may stem from the fact that the industry has been preoccupied with the task of expanding its facilities under the restrictions of government regulation as isolated monopolies. Although tremendous progress has been made, instances where sharp changes in engineering practice occurred in response to new developments in science were rare. As unrestricted money for the sponsorship of on-campus research by students and faculty were almost nonexistent, power option faculties decreased in number and the students were drilled almost wholly in the solved art of the past within the power industry. Their bandwidth was from 0 to 60 cycles. Much teaching equipment supporting this field was allowed to become old, and by comparison with electronics and communications, was ponderous, inflexible, and lacking in scope for the cultivation of student resourcefulness.

The academic atrophy that now exists in this field disturbs educators as continued growth of the economy necessitates expanding the base of electric power. Complex processes of energy conversion, control, and utilization requiring engineering skill of the highest order continue to increase. Already there are nuclear fission, solid-state energy converters such as the solar battery, supersonic aviation, high-temperature metallurgy, chemical synthesis, and many others. These, coupled with major advances in magnetic, dielectric, and semiconductor materials which permit wholly new solid-state devices, will expand the field and create a great need for a new type of engineer. But as power engineering has been presented to students, it has failed to attract sufficient numbers with sufficiently high intellectual ability and creative breadth to meet the needs.[4] On nearly every campus power engineering has become the poor relation, both financially and intellectually, by contrast with the fields that support the mission to process and transmit information. A sharp and decisive reversal of this situation is needed.

A SUGGESTED BREAK WITH TRADITION

The faculty of the department of electrical engineering at the Massachusetts Institute of Technology has conducted a harsh review of its own practices relative to these matters. It has drastically revised its undergraduate curriculum: first, to broaden and deepen the science instruction for all students; second, to strengthen its training in electrical engineering by a revision of its laboratory facilities to permit more creative work by students with better integration of the sciences; third, to preserve equal opportunity for every student to choose his subsequent career by subordinating mention of vocational aspects of electrical engineering until a strong science foundation has been established; and fourth, to recognize the wide variety of interest and talent among students by allowing a wide choice of elective study in the senior year.[5] It is now clear that the break with tradition must be so great that it will take several years to learn how to achieve these aims.

As initial moves toward these aims, the department has:

1. Abandoned all educational plans based on vocational options and established a core curriculum for all electrical majors.[6]

2. Discontinued instruction in traditional a-c and d-c machinery and disposed of much conventional equipment in its machinery laboratory.

3. Initiated new subjects of instruction for about half of its core curriculum to broaden and deepen the student's understanding of the science of fields, materials, and energy conversion.

4. Initiated the development of new laboratory doctrines and facilities to focus a student's attention on the objectives of laboratory investigation rather than on instruments, methods, or techniques, and to afford him a tangible opportunity to study the fundamental concepts of science and to synthesize devices and engineering systems illustrative of them.

5. Attempted to revitalize the old field of power by initiating graduate student and staff research in the broader field of energy conversion, control, and utilization.

The precise meaning of this approach is best illustrated by reference to some of the subjects that are offered.

THE REVISED CURRICULUM

The arrangement of the curriculum is shown in tabular form in Table I. The work of the electrical department begins in the sophomore year with a 2-term sequence on circuit theory, including laboratory studies on circuits and circuit elements. The treatment is broad. About 80 per cent of the book, "Introductory Circuit Theory," by E. A. Guillemin, together with supplementary notes, is used as text material. Methods of analyzing nonlinear as well as linear circuits, appropriate to power as well as to communications, are emphasized. Statics is treated as a special case of dynamics. Computational aids, such as analogue computers, are mentioned to encourage students to attack advanced practical problems.

Table I. Electrical Engineering at MIT, 195–545

Freshman				
Physics	Chemistry	Mathematics	Elective	Humanities
Physics	Chemistry	Mathematics	Elective	Humanities
Sophomore				
Physics	Electric circuits, 6.00	Mathematics	Applied mechanics	Humanities
Physics	Electric circuits, 6.01	Mathematics	Applied mechanics	Humanities
Junior				
Electronic circuits 6.02	Fields, materials and components 6.03	Mathematics	Thermo	Humanities
Applied electronics 6.05	Elec. energy convertors, 6.04	2 Electives—both out of department		Humanities
Senior				
Energy transmission and radiation 6.07	Power modulators 6.06	2 Electives—inside or outside department		Humanities
Integration of above courses via free electives influenced by student's aptitudes and interests		Thesis		Humanities

Leads to commencement followed by

Graduate study and research, SM, EE, ScD

On-the-job training in industry, or self development by the graduate

Note: Subjects 6.00 through 6.07 include both classroom and laboratory. Both Junior and Senior subjects are influenced by research of faculty and graduates students,

While the sophomore students study circuit theory, they also study humanities, applied mechanics, physics with emphasis on fields, and mathematics up through differential equations.

TWO MAIN STEMS

The electrical subjects of the junior year comprise two main stems. The stems are not options. They blend with each other as they develop, and as teaching personnel transfer back and forth between subjects. They extend into the first term of the senior year and broadly support the two missions discussed. One stem treats the role of electronic devices and the basic principles of application of such devices to perform electrical engineering functions such as rectification, amplification, modulation, oscillation, and energy radiation and transmission, as related appropriately to both information, and energy processing by electronic systems. The other stem treats fields, materials, devices, and engineering functions such as energy conversion, power modulation, and control, with emphasis on higher power systems. The approach followed in the development of both stems exploits the conceptual model by showing the student that an electrical engineer has unique ability to exploit electric charges and their associated electric and magnetic fields in engineering problems, that all devices are built of materials, and that materials interact with the fields. From this elementary viewpoint, he is led to appreciate that all electric systems are basically the result of a creative engineer's ability to exploit the combination of fields and materials to accomplish specific needs. Accordingly, instead of training students as in the past, merely to understand traditional devices such as transformers, motors, generators, or specific kinds of amplifiers, a broader comprehension of a scientific background is coupled with the basic mission of electrical engineers.

THE ENERGY-CONVERSION STEM

The third year work in the energy stem builds on the second year work in physics. The content of this stem is treated in some detail because it represents the major change in the curriculum.

The first subject, Fields, Materials, and Components, is a cornerstone in the new program. It is still in the trial stage. As now offered, it treats electromagnetism starting from Maxwell's equations, and emphasizes the relationship between fields and network parameters and the physical bases of the electric and magnetic properties of materials. It aims to introduce the universality of the field theory throughout the entire range of electrical engineering as it relates to the operation of circuit components, energy-transfer devices, and energy converters. The student is brought into first contact with the atomic structure aspects of materials, both as to their known properties and as to why they have these properties. It is hoped to show him at an elementary level something of the scope that lies ahead in the exploitation of new kinds of materials in electrical engineering. In the laboratory the students plot and measure 2- and 3-dimensional fields for diverse boundary conditions, conduct elementary studies on dielectric and magnetic materials with a view to relating microscopic behavior to atomic structure, and investigate quasi-static lumped parameters.

The second subject of this stem, Electrical Energy Converters, compares the various methods of electric energy conversion, and emphasizes the importance of electricity as the transport medium for energy of all levels and functions. It illustrates the importance of electromechanical energy conversion and justifies an emphasis on this process and on its devices. The point is made that the electromechanical energy conversion process manifests itself by its effects on the connected systems in the form of forces, voltages and currents, which are the reactions of the coupling fields on the conducting, dielectric, and magnetic boundaries of the device. The student is shown that the behavior can be determined either by integrating the reactions over the boundary surfaces, or by resorting to the concepts of equilibrium and virtual work, leading to the generalized treatment of energies and the use of Lagrange's equation.

These principles are applied to devices ranging in construction from the simple 1-circuit transducer to the multicircuit rotating machine and in function from the signal and instrumentation devices to the bulk energy converters. Energy flow in these devices is traced through the fields. Analysis is carried out by linear and nonlinear circuit techniques. System representations are made in terms of appropriate functions. Laboratory experience with typical devices complements the analysis.

The mission of this subject is to set the background for the study of energy-conversion devices in systems and to prepare the student for the apparent trend in this field toward more sensitive transducers, more controllable conversion devices—conversion devices operating at higher speed, frequencies, and temperatures—and the use of new direct solar-, thermal-, chemical-, and nuclear-electric conversion methods to supply the energy needs of tomorrow.

The third subject, Power Modulators, treats the dynamics of energy conversion and control devices with specific emphasis on devices used at higher-power levels. The dynamics of energy-conversion devices always involve nonlinear differential equations, and general solutions to these equations are not obtainable. The study of device dynamics, therefore, requires that complete systems be considered in order to make reasonable approximations and simplifications.

Power modulators and their connected systems are studied using elementary feedback concepts and terminology. This includes the concept of gain and time constant of first-order systems, the relationship between frequency response and time response of linear systems, the ideas of absolute and relative stability, and graphic methods for representing system response.

Two important classes of power modulator are treated. The first embraces electric transfer devices in which the input, the output, and the control are all electrical quantities. The modulation properties of these devices are related to the functional nonlinearities of the electrical parameters. Typical examples of this class of power modulator are the switching-type amplifiers, such as magnetic and thyratron amplifiers.

The second class of power modulator is the electrome-

chanical converter. This modulator is capable of controlling the flow of relatively large quantities of energy between two electric systems by means of mechanical command signals, or it is capable of controlling the conversion of energy from a mechanical system to an electric system by an electric or mechanical command signal. The modulating or controlling characteristics of these modulators are made possible by designing the devices so as to allow mechanical freedom of motion between current-carrying conductors or coils. Examples are the commutator-type a-c and d-c machine, induction machines such as the servomotor, and synchronous machines under steady-state or quasi-steady-state operation.

The dynamic analysis of power modulators is treated using electric-circuit methods rather than electromagnetic field methods. The equations of motion for the power modulators are obtained from Lagrange's equation, and matrix algebra is used to reduce these equations to forms best suited for each application. Throughout the subject, dynamics and control concepts are stressed and steady-state concepts are minimized.

Laboratory studies with devices and systems are being developed to support the classroom analysis. Most notable is the extent to which electronic techniques have entered the laboratory activity. The task of devising and building laboratory facilities for these energy conversion and power modulation subjects that will yield tangible opportunities for resourcefulness by the student offers one of the big challenges in the whole program. It is proceeding.

THE INFORMATION-PROCESSING STEM

In the information-processing stem, each student studies a 2-term sequence of electronics, Electronic Circuits and Applied Electronics, to show the role of electronic devices in modern technology. The sequence introduces methods of representing a nonlinear device such as the high-vacuum or gas tube and the transistor, and it leads to a concept of piece-wise linear or linear-incremental circuit models. It treats functions such as amplification, modulation, oscillation, information processing, and limitations on system behavior from such factors as nonlinearity, noise, and the effects of inherent residual circuit parameters. It leads to the synthesis of simple electronic systems for specific objectives. Each student draws on the resources of a well-equipped laboratory.

The third subject of this stem, Energy Transmission and Radiation, also correlates closely with the first subject in the energy stem. It treats wave motion, its behavior in physical structures having dimensions comparable with the wavelength, and its specific application to energy transmission and radiation. It reviews the relations between dynamic fields and lumped circuits, and extends these to the concepts of wave impedance and radiation impedance. The laboratory for this third subject offers the opportunity to investigate quantitatively such topics as the limitations of lumped constant models in electrical and acoustical environments, 1-dimensional wave motion on transmission lines, 2-dimensional wave motion in plane waves, and elementary radiation and diffraction patterns in space.

LABORATORY INSTRUCTION

Laboratory work is a regular part of each core subject and is directed at the technical and professional growth of the student on a broad plane. In addition to illuminating in a practical way the classroom theory, the laboratories provide an integrated series of organized experiences which develop engineering judgment, ability to plan, confidence in making compromises, teamwork, ability to observe effectively, skill at technical writing, and independent creative thought and initiative. Many of these objectives are served by an organizational pattern whereby the student is required to assume a progressively increased responsibility for the planning and execution of his laboratory work, over and above the mere mastery of experimental facts and techniques. For example, during the sophomore year the student is, among other things, made aware of laboratory equipment and effective experimental method by means of a series of problems which always yield a few challenging surprises. During the junior year the students themselves, with periodic counsel from assigned instructors, plan their attack on problems and select the equipment to be used. The instructor, should subtly hold the student's attention on the objectives of the study to offset his tendency to become preoccupied with mere instruments and the taking of data. During the senior year the student is urged to take the additional step toward creative thought and initiative by defining problems at the frontiers of his experience and interests around an idea, by decomposing the idea himself, and by carrying through to a formal engineering paper.

The laboratory instruction and the facilities for about one-half of the revised curriculum are in the first stage of a process which will converge by means of successive approximations. Laboratory topics are being filtered for adoption or discard at a rapid rate as the staff appraises its total accomplishment. It has been learned that students should not be hurried in the laboratory, and experiments should be physically simple but technically comprehensive, with a view to developing in the student a true sense of scientific inquiry.

ELECTIVES

Each student must elect at least one humanities subject each term, with the stipulation that the humanities sequence establish some depth in at least one area. In his junior year he must, each term, also carry two elective subjects outside of the electrical department. For many students the faculty suggests that these electives comprise a third year of mathematics and a third year of physics pointed toward modern physics. One-half the load for the first term of the senior year comprises the two remaining subjects of the stem sequence. The rest of the senior year comprises the two subjects in humanities, five professional electives, and a thesis.

Wide latitude is allowed students in the selection of professional electives. Students interested in graduate work, or research and development in a creative technical environment, are advised to elect scientific or abstract subjects—for example, advanced mathematics, solid state physics, molecular phenomena of materials and their tech-

nical applications. It is felt these students will have received broad training in electrical science as well as training in electrical engineering. On the other hand, those students who tend to be form- or thing-conscious, rather than abstract-idea conscious, or who have a high degree of tangible ingenuity in contrast with sharply developed skill at creative scientific reasoning, are advised to choose electives from a wide range of more practical topics, either in or out of the department. These electives may comprise manufacturing, management, engineering design, or such electrical engineering subjects as Feedback Control Principles, Electrical Implementation, Principles of Radar, Machine-Aided Analysis, Electronic Control and Measurement, Communication System Engineering, or Engineering Acoustics, depending upon each student's talents and interests.

CONCLUSION

It is hoped that a program will be achieved which will equip students with the technical substance and professional vision needed for sustained creative development, and backed up by a deep sense of their social responsibility.

Work on the program has just begun. All the subjects in the energy-conversion stem are new, as are about half of the content of the information-processing stem. The third subjects in each stem were offered to students for the first time in the fall term of 1954. The first class to have studied under the new program will graduate in June of 1955.

The accomplishments to date are pleasing, but they are still considered far from satisfactory. It is expected that the core subject substance and the laboratory facilities will need reworking for 3 or 4 years. The skill and technique for presenting the material to the students needs much improvement. New class notes, with related problems, are being prepared for five of the eight core subjects.

It is felt engineering students are unlikely to be motivated by a straight mathematics and science curriculum. Therefore, a virile evolving curriculum, well integrated with real engineering problems and a challenging laboratory program, led by a sincere faculty, are essential.

A research program has yet to be established in the area of energy conversion of a magnitude and at a pace that the program needs. It is felt that without a vigorous faculty research effort, the program will not long endure.

ACKNOWLEDGMENTS

The co-operation of the students is warmly acknowledged. To put it mildly their response has been good and the going has been difficult. An attempt has been made to keep them fully informed. They sense a partnership in an educational experiment and have shown unusual adaptability and versatility.

The staff of the department is enthusiastic about the program. The burden is heavy for all and especially heavy for the many who are evolving the new core subjects. The creative imagination and heavy personal sacrifice of all are gratefully acknowledged.

REFERENCES

1. Interim Report of the Committee on Evaluation of Engineering Education. *Journal of Engineering Education*, Lancaster, Pa., vol. 45, no. 1, Sept. 1954, p. 40.

2. Letter to A College President, **H. L. Hazen.** *Electrical Engineering*, vol. 73, May 1954, pp. 391–5.

3. The Universities and the Engineering World, **B. L. Goodlet.** *Transactions*, South African Institute of Electrical Engineers, Johannesburg, Transvaal, Union of South Africa, August 1950.

4. The Manpower Shortage in Power Education, **J. D. Ryder.** *Electrical Engineering*, vol. 72, January 1953, pp. 25–27.

5. The Modern Engineer Should Be Educated as a Scientist, **G. S. Brown.** *Journal of Engineering Education*, Lancaster, Pa., vol. 43, no. 4, December 1952.

6. Integration versus Options in Electrical Engineering, **G. S. Brown.** *Engineering*, vol. 72, July 1953, pp. 595–97.

Utility Boasts Biggest Snubbers Ever Made

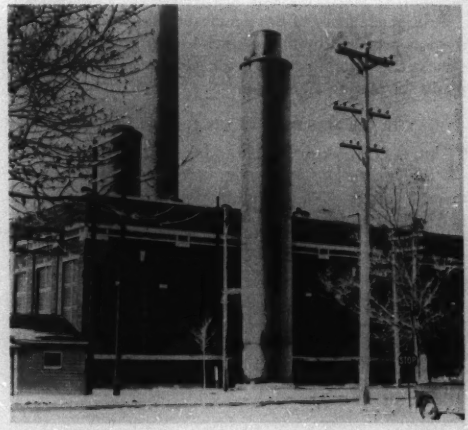
These two giant silencers, installed in a midwestern utility company are reported to be the biggest ever made, according to the manufacturers, Burgess-Manning Company, pioneer industrial noise abating equipment company, Libertyville, Ill.

Each snubber is 74 feet high, 12 feet in diameter, and weighs 70,000 pounds. These giant silencers are so big that they had to be shipped in three sections for installation.

Various acoustic tests on the snubbers have been completed and they are working effectively. They are designed to silence the exhaust of two 5,000-kw simple cycle gas turbine generating units.

Snubbers are used for subduing many types of industrial noise from steam exhausts and ejectors, internal combustion engines, compressors, blowers, vacuum pumps, and air intake.

The snubbers are also utilized for various other purposes such as surge control.



Nuclear Power Plants for Ship-Propulsion Application

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The application of atomic power to the *C-4* Mariner-Class cargo vessel is analyzed in some detail. It shows that at present nuclear power cannot compete on a strictly economic basis with conventional power plants. However, other factors such as weight, space, speed, and range considerations would also enter into any complete evaluation of the application of atomic power for marine purposes.

At the present time a great deal of interest is being shown in the possible use of nuclear energy for many commercial applications including shipping. Unfortunately, little information directly applicable to marine applications has been released by the Atomic Energy Commission (AEC). The AEC, however, has declassified a significant amount of data on land-based atomic power plants and particularly on proposals made by private-industry study groups.

This article is an initial result of a Westinghouse study of a possible application of nuclear power. The study is covered by an industrial-participation contract with AEC and is financed by Westinghouse.

In this article, the land-based plant information is used to give some insight into the possible application of atomic power for propulsion of merchant vessels and particularly the *C-4* Mariner-Class cargo vessel. Principal emphasis is given to the economic aspects of this new energy source. An economic comparison is made between nuclear and conventional fuels for the *C-4* operating at normal power and in normal service. Certain factors that may influence the application of atomic power, such as, released fuel-oil space and weight, longer cruising distances between refueling operations, higher vessel speeds, etc., are discussed. Military advantages of atomic power, although very significant, are not reviewed in this article.

A brief summary of the significant characteristics of the reactors proposed by the industrial study groups will show some of the factors involved in the selection of nuclear power plants for marine applications.

THE C-4 MARINER CLASS CARGO VESSEL

The *C-4* cargo vessel of the Mariner Class[1,2] will be used to illustrate the application of atomic power to commercial vessels. The *C-4* propulsion plant has an output of 17,500 shaft hp at a cruising speed of 20 knots, and a maximum output of 19,250 shaft hp. The capital investment requirements for this vessel are summarized in Table I.[3] For present purposes, the power plant will be treated independently of the rest of the vessel, so consideration need be given only to the first two capital investment figures in the table. This procedure is adequate when comparing two power plants that are designed to deliver the same shaft hp, which will be done in this article.

Table I. C-4 Mariner Class Cargo Vessel Capital Investment Requirements

Turbines, shaft, screw, etc.	$ 2,000,000
Boilers and auxiliary equipment	500,000
Hull and fittings	6,000,000
Miscellaneous facilities and working capital	5,000,000
	13,500,000

In an economic comparison of power plants, the following cost factors should be included: operation; maintenance and repair; capital costs—interest, depreciation, insurance; and fuel.

Whereas data are available on the operating costs of conventional marine power plants, corresponding information on the cost of operating an atomic marine plant is not available. For this reason, the assumption will be made that operating costs are the same for the two plants. This assumption will suffice for present purposes, particularly if special costs associated with the handling of nuclear fuels are included in the cost of the fuel.

MacMillan and Ireland,[4] included maintenance and repair costs at 1.5 per cent of the capital investment in the power plant, which allows for an increase in these costs with investment. This same assumption will be made; however, its significance will be discussed later.

The capital costs given in Table II were used by MacMillan and Ireland[4] and the same values will be adopted in this article. The 9.5 per cent total for the first three items is intended to represent average annual charges over a 20-

Table II. Fixed Charges on Investment

	Per Cent
Interest	2.6
Depreciation	4.9
Insurance	2.0
Maintenance and repair	1.5
	11.0

Full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954, and recommended for publication by the AIEE Committee on Nucleonics.

R. L. Witzke and S. A. Haverstick are both with Westinghouse Electric Corporation, Pittsburgh, Pa.

year plant life. Adding maintenance and repair at 1.5 per cent results in a total annual fixed charge on investment of 11 per cent. Such items as overhead, taxes, and profit normally are not related to a marine power plant so are not included.[4] The annual fixed charges will be varied over a range of 9 to 13 per cent to show the influence of this factor on the economic comparisons.

Fuel costs will be retained as a primary variable in comparing conventional and nuclear fuels. The cost of fuel oil will be varied over a range of $2.00 to $4.00 per barrel. A fuel oil density of 340 pounds per barrel and an energy content of 18,500 Btu per pound will be used.

In combining fuel and capital costs it is necessary to take into account annual load factor. MacMillan and Ireland based their conclusions on a load factor of 60 per cent for cargo vessels and 90 per cent for tankers. The Harvard Report[3] assumed 170 days at sea at 10,000 shaft hp in a study of the *C-4* cargo vessel. Considering both the days at sea and the "less than full power" operation, the latter is equivalent to a load factor of 26.6 per cent. A range in load factor from 25 to 100 per cent will be considered.

Table III. Reactors Proposed by Industrial Study Groups

Reactor	Fuel	Moderator	Coolant	Coolant Temperature F In	Coolant Temperature F Out	Pressure Vessel Diameter	Pressure Vessel Height, Feet
I	Natural uranium	D_2O	D_2O	388	440	20-foot sphere, 800 psi	
II	Slightly enriched uranium	H_2O	H_2O	369	440	12-feet, 800 psi	39
III	Natural uranium	D_2O	H_2O	384	500	Not Designed	
IV	Slightly enriched uranium	Graphite	Sodium	300	650	35 feet (core size)	20
V	Slightly enriched uranium	Graphite	Sodium	300	900	35 feet (core size)	20
VI	Highly enriched uranium	None Used	Sodium	600	900	3 feet (core size)	3

I, II—Commonwealth Edison Company–Public Service Company of Northern Illinois.
III, VI—Pacific Gas and Electric Company–Bechtel Corporation.
IV, V—Monsanto Chemical Company–Union Electric Company of Missouri.

Table IV. Rating and Cost of Land-Based Atomic Power Plants Proposed by Industrial Study Groups

Reactor	Reactor Heat Output: Mw	Electrical Output-Mw Gross	Electrical Output-Mw Net	Estimated Plant Cost Total in Millions	Estimated Plant Cost Per Net Electric Kw
I	1,064	266	212	$118	$556*
II	1,234		246	73	296
III†	500	106	101	41	406*
IV	1,000		210	100	476
V	3,000		554	156	282
VI†	500	155	145	51	352

*Includes D_2O at $80 per pound.
†III, VI—Same as Table III.

STEAM PRODUCTION COSTS

At normal power and service, the *C-4* cargo vessel consumes 9,100 pounds of oil per hour based on 18,500 Btu per pound of fuel oil. Using a boiler efficiency of 88 per cent, the boiler output is 148 million Btu per hour or 43,500 kilowatts. At 340 pounds of oil per barrel, the hourly fuel consumption to obtain this boiler heat output is 26.8 barrels. The annual steam production costs, which include the cost of fuel as well as the annual fixed charges on the boiler plant investment, can be obtained as follows:

$$P = C/100 \text{ (boiler cost)} + Lf/100\ (235{,}000), \text{ where} \qquad (1)$$

P = annual steam production cost in dollars
C = per cent annual fixed charges on investment
L = per cent annual load factor
f = cost of fuel oil in dollars per barrel

The figure in the second term of the equation is the annual fuel oil consumption at 100-per-cent load factor, based on 8,760 hours and 26.8 barrels per hour.

THE REACTOR PLANT

In this presentation, the reactor plant, which includes the reactor and its associated equipment, is a steam production plant that replaces the conventional oil-fired boiler. A possible arrangement of a reactor plant is illustrated in Fig. 1.[1] The heat, which is produced by fissioning atoms in the fuel elements in the reactor, is removed from the reactor by a coolant, and transferred to heat exchangers where it is used to produce steam. The entire reactor plant is surrounded by heavy shielding to protect operating personnel from the intense radiations produced by nuclear fission within the reactor. The reactor is controlled by means of control rods inserted into the reactor core.

The steam turbines and associated equipment for an atomic plant would essentially be the same as in a conventional oil-fired plant.

Assuming Uranium 235 (U-235) as the fuel in a reactor

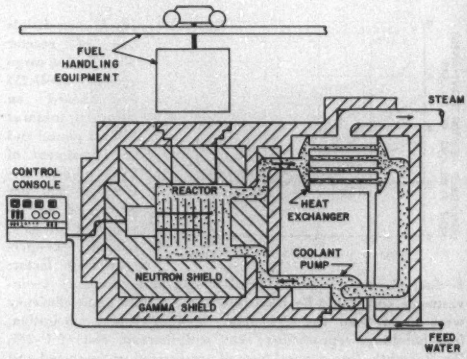

Fig. 1. A typical reactor plant

Table V. Estimated Cost of Reactor Plants Proposed by Industrial Study Groups

Reactor	Steam Temperature, F	Estimated Costs: Turbine-Electric Plant $/Kw	Estimated Costs: Reactor Plant Millions of $
I	371	137	89
II	369 estimate	137	39.1
III†	378	147	26.2
IV	360	140	70.5
V	746	90	106
VI†	750	110	35.1

†III, VI—Same as Table III

Table VI. The C-4 Mariner Class Cargo Vessel

Shaft hp, maximum	19,250
Shaft hp, normal	17,500
Speed, knots	20
Fuel oil, maximum capacity, tons	3,808
Boiler output, normal power, normal service:	
Shaft hp	17,500
Fuel consumption, pound per hour	9,100
Heating value of fuel, Btu per pound	18,500
Approximate boiler efficiency, per cent	88
Boiler output, millions of Btu per hr	148
Boiler output, megawatts	43.5
Superheater outlet pressure, psig	600
Superheater outlet temperature, F	865

plant, an equation can be derived for steam production costs in the nuclear plant. The energy released per gram of U-235 consumed is approximately 20,000 kilowatt hours, so 2.175 grams of U-235 would be required per hour to produce the same heat output as 26.8 barrels of oil. A total annual consumption of 19,100 grams would be required to operate the *C-4* at 100-per-cent load factor. The annual steam production costs can then be determined as follows:

$$P = C/100 \text{ (reactor plant cost)} + Ln/100 \text{ (19,100), where} \qquad (2)$$

P = annual steam production cost in dollars
n = cost of U-235 in dollars per gram

If the reactor plant is to compete on an economic basis with the conventional boiler, the annual steam production costs must be as low as for the conventional plant.

PERMISSIBLE REACTOR PLANT COSTS

Based on the relations developed in the previous sections, it is possible to determine permissible reactor-plant investment costs as a function of the cost of nuclear fuel. In order to simplify the required steps, this will be done first for annual fixed charges of 11 per cent, a load factor of 50 per cent, and fuel oil at $3.00 per barrel. Under these conditions, and using the *C-4* boiler cost of $500,000, the annual steam production cost is $407,000, using conventional fuel. Substituting the above values in equation 2, the permissible reactor plant cost is equal to 3,700,000—86,800 n dollars. This cost is plotted in Fig. 2 for a range of nuclear fuel costs. This method of plotting permissible investment and nuclear fuel cost is similar to the one adopted by Walker Cisler for land-based plants.[5]

It will be noted that with the 50-per-cent load factor, reactor-plant cost cannot exceed $3,700,000 even with zero nuclear fuel cost; and with zero investment cost, the fuel cost cannot exceed $42.70 per gram.

Also plotted in Fig. 2 are corresponding curves for other load factors, the data being obtained in the same manner as for the 50-per-cent load-factor case.

REACTOR TYPES

It is of interest to compare the permissible costs in Fig. 2 with available unclassified investment and fuel costs. However, the essential characteristics of a number of reactors will be discussed first.

One general form that a water-cooled and -moderated reactor might take is shown in Fig. 3. It is not patterned after any actual reactor but will serve to illustrate the operation of water-cooled reactors. In this figure the reactor core is located inside a spherical pressure vessel. The core itself is in the form of a right cylinder and constructed somewhat like a fire tube boiler with the tube sheets at the top and bottom. Coolant channels between these tube sheets contain the fuel elements. The cooling water passes through the annulus between the fuel element and the coolant channel. As shown in this figure, the moderator, which fills the space between the coolant channels, is circulated through a separate external circuit for heat-removal purposes. Details relating to control, fuel handling,

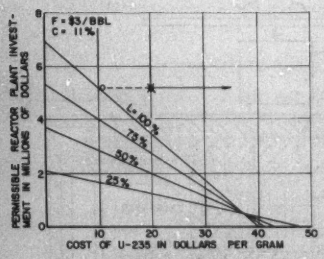

Fig. 2. Permissible cost of reactor plant for *C-4* cargo vessel. o—U-235 cost based on natural uranium at $35 per pound and an investment of $5¼ million; x—U-235 at $20 per gram and an investment of $5¼ million; L—per-cent load factor; F—fuel oil cost; C—annual fixed charge on investment; A—investment cost would be increased if the atomic plant efficiency were lower than the C-4 plant; B—fuel element fabrication, fuel handling, reprocessing, etc. will increase cost of U-235.

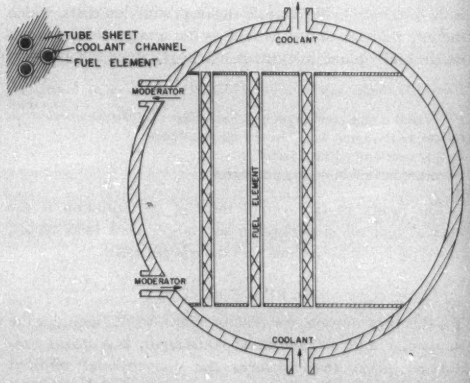

Fig. 3 (right). One general form of pressurized water-cooled and -moderated reactor

etc., have been omitted from the illustration because their discussion is beyond the scope of this article.

In reactors that use a common fluid to perform the function of the coolant and moderator, a separate moderator cooling circuit may not be required. Reactor I in Table III, IV, and V is a heavy-water-moderated and -cooled reactor using natural uranium as a fuel.[6,7] The pressure vessel is a 20-foot sphere pressurized at 800 psi. Reactor II uses light water as the coolant and moderator and slightly enriched uranium as the fuel.[7] Reactor III is a heavy-water-moderated and light-water-cooled reactor fueled with natural uranium.[6,7]

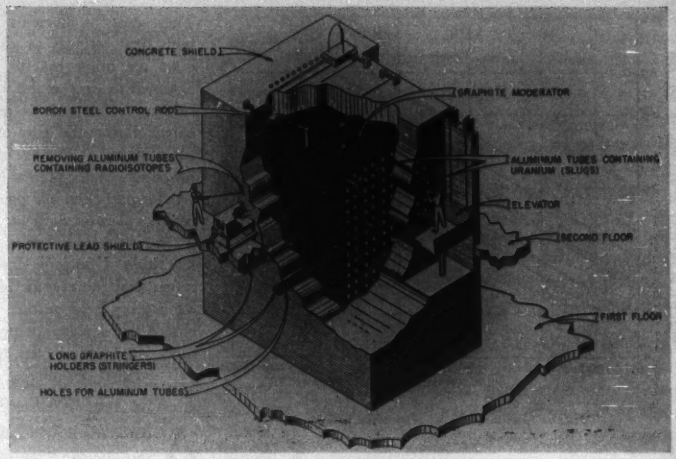

Fig. 4. The graphite-moderated reactor

The large graphite-moderated reactor similar to the ones at Oak Ridge and Hanford is shown in Fig. 4. Their mass is principally graphite and they are fueled with natural uranium. In this illustration the fuel is in the from of slugs located in horizontal fuel channels.[8]

The Hanford reactors are water cooled and are operated at relatively low temperatures. The heat produced is dumped because the temperatures are too low for practical power production.

Reactors IV and V in Tables III, IV, and V are graphite moderated but use sodium as the coolant in order to obtain reasonable temperatures without a pressurized system.[6,7] These reactors require slightly enriched uranium in place of natural uranium for their fuel.

The experimental breeder reactor at Arco, Idaho[9] is shown in Fig. 5. The declassified literature states that the core of this reactor is about the size of a regulation football. The core is surrounded by what is referred to as a breeding blanket. Neutrons that escape from the small core are absorbed by the U-238 in the blanket, the U-238 being converted to plutonium. This type reactor does not use a moderator and depends on fast neutrons to produce fission. Liquid metal rather than water is used as the coolant.

In the fast breeder as proposed by the Pacific Gas and Electric Company–Bechtel Corporation Study Group, reactor VI in the tables, the core is roughly 3 feet in diameter and 3 feet high and contains highly enriched fuel material.[6,7] The diameter outside of the breeding blanket is about 8 feet.

REACTOR PLANT COSTS

A summary of the estimated cost of the six atomic power plants proposed by the industrial study groups[6,7] is given in Table IV. The cost estimates include the reactor plant, which is the steam production portion of the atomic power plant, as well as the turbine-electric plant. The figures for reactors I and III include the cost of the required heavy water. The costs in Table IV were taken directly from unclassified AEC reports[6] and from one *Electrical World* article.[7] Table V is an estimate of the cost of the reactor plants without the turbine-electric portion of the total plant. In some cases the published information did not include separate figures for the reactor plants, so estimates had to be made. This was done by estimating the cost of the turbine-electric portion of the plant for the steam conditions arrived at by the study groups. Average costs from Federal Power Commission reports were obtained and then modified for the steam flows

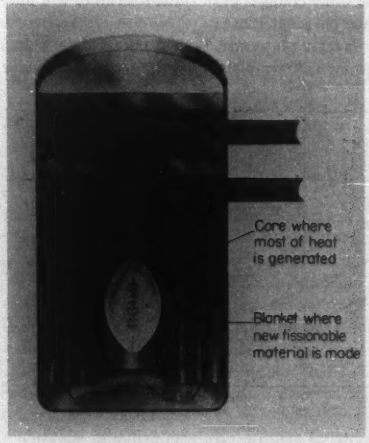

Fig. 5. Artists conception of experimental breeder reactor

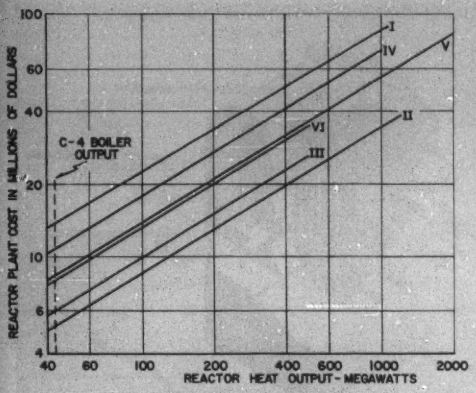

Fig. 6. Estimated cost of reactor plants

Reactor	Moderator	Coolant
I	D_2O	D_2O
II	H_2O	H_2O
III	D_2O	H_2O
IV	*Graphite*	*Na*
V	*Graphite*	*Na*
VI	*None*	*Na*

that would be encountered in the nuclear plants. In estimating the costs for reactor II, the turbine steam temperature was assumed because no value was given in the unclassified literature. A comparison of Table III and V will show that the steam temperature for the water-cooled reactors is slightly lower than the reactor coolant inlet temperature. In the case of reactor II, a steam temperature equal to the reactor coolant inlet temperature was assumed. This assumption is adequate for present purposes because small changes in steam temperature will have little influence on plant cost.

The reactor plant cost is then obtained by subtracting the turbine-electric plant cost from the total plant cost. These costs as given in Table V apply for reactor plants with heat outputs as given in Table IV. In evaluating costs for other reactor thermal outputs the costs were assumed to vary as the 0.6 power of the heat output of the reactor. This rule is used in the chemical industry for extrapolating the cost of process plants as a function of plant output. The use of this same rule has not been established for reactor plants; however, the similarity between the reactor and chemical process plants indicates that the costs of these plants should vary in somewhat the same manner.

The estimated costs of the six plants are plotted in Fig. 6 for thermal outputs down to 40 megawatts. It will be noted that the reactor plant costs vary over a wide range for a given heat output, the cost of the heavy-water-moderated and -cooled being the highest and the light-water-moderated and -cooled the lowest.

A COST COMPARISON

A comparison will now be made between conventional and nuclear steam-production plants.

As shown in Table VI, the boiler output of the *C-4* at normal power is 43.5 megawatts. Referring to Fig. 6, the lowest reactor plant cost with this heat output is $5^1/_4$ million dollars, which is for the light-water-moderated and -cooled reactor.

Very little unclassified information is available on the cost of nuclear fuels. Dr. Zinn used a cost of $35.00 per pound for natural uranium and $20.00 per gram for U-235.[9] In the article Dr. Hafstad is quoted as saying, "the $20 per gram figure is almost certainly low;" so it can be seen that the available information is somewhat limited in value. Dr. Zinn's figures, however, will be used because no other ones are available.

It should be noted that the light-water-moderated and -cooled reactor, as proposed by the Commonwealth Edison Company, used slightly enriched uranium as a fuel. The cost figures in Fig. 6 were obtained by varying the reactor plant cost as the 0.6 power of the heat output, which assumes that the size of the reactor must decrease somewhat in proportion to the reactor heat output. As the reactor size is decreased, the fuel enrichment must be

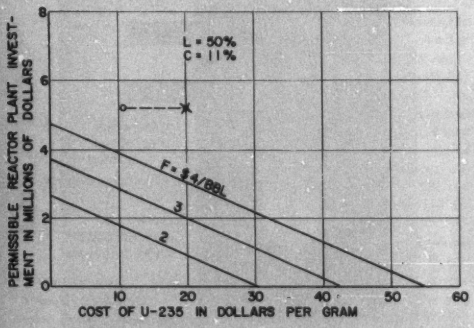

Fig. 7. Influence of fuel-oil cost on permissible reactor-plant cost. Note: See Fig. 2 for nomenclature

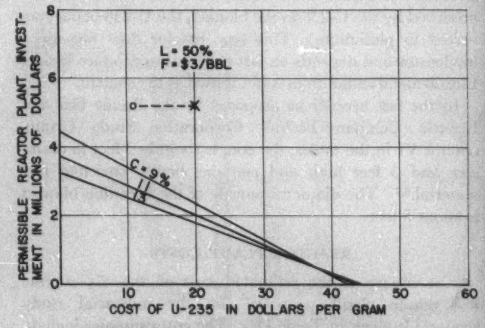

Fig. 8. Influence of annual fixed charge on permissible reactor-plant cost. Note: See Fig. 2 for nomenclature

increased in order to compensate for the higher neutron leakage in small reactors. The actual enrichment required for the *C-4* application cannot be determined from the available information. Furthermore, the cost of uranium as a function of enrichment cannot be established at this time. Using Dr. Zinn's figures for natural uranium and U-235, the cost of enriched uranium, however, can be bracketed. As one pound of natural uranium contains 3.23 grams of U-235, the cost of the contained U-235 is $10.80 per gram, based on $35 a pound for natural uranium. The cost of enriched uranium therefore should fall between $10.80 and $20 per gram of U-235.

Referring to Fig. 2, the circle represents costs of $10.80 per gram for U-235 and $5^1/_4$ million dollars for the reactor plant. The cross represents the same investment cost, but with U-235 at $20 per gram. It is evident that with present cost figures and reasonable load factors, nuclear energy cannot compete on a straight economic basis with conventional fuel. It should be borne in mind, however, that the cost figures used in this analysis are based on a new and undeveloped technology, and that technical progress will result in significant cost reductions.

The investment cost in Fig. 2 is based on a reactor plant having the same heat output as the *C-4* boiler plant, the latter producing steam at 600 psig and 865 F. If the reactor plant produces steam at a lower temperature than the *C-4* plant, its heat output will be higher than the *C-4* boiler. Of course, this would have an influence on the cost of the reactor plant. The reactor on which the cost data in Fig. 2 is based is designed for relatively low temperatures. It, however, was designed for plutonium as well as power production. A single-purpose plant, producing power only, no doubt would be designed for higher steam temperatures. If the steam conditions influence the cost of the turbine plant, the permissible reactor-plant cost must be modified accordingly.

The cost range of $10.80 to $20 per gram for U-235 assumes no charges for fuel-element fabrication, fuel reprocessing, or capital charges on fuel inventory, all of which will increase the nuclear fuel cost.

The influence of fuel-oil cost on permissible reactor-plant cost is shown in Fig. 7. It is based on a 50-per-cent load factor and an annual fixed charge rate of 11 per cent. Fig. 8 illustrates the influence of variations in the annual fixed-charge rate.

OTHER TANGIBLE AND INTANGIBLE FACTORS

Other factors that will influence marine application of atomic power include space and weight, speed and cruising range considerations, etc. The *C-4* cargo vessel has capacity for 3,800 tons of fuel oil, all of which would not be required with a nuclear power plant. The nuclear plant, including shielding, probably will weigh more than the conventional boiler plant. However, considering both plant and fuel, a net-weight savings should result. A detailed study, possibly including a vessel design, would be required to evaluate these weight factors.

The small space and weight associated with nuclear fuels make it practicable to design for long cruising ranges between refueling operations, which will have merit in some applications. Higher speeds, with reasonable cruising ranges, also are more readily obtained with nuclear plants, because of fuel space and weight considerations.

SUMMARY AND CONCLUSIONS

In this article, the available declassified information on land-based atomic power plants is used to give some insight into the possible application of atomic power for ship propulsion. The application of this new energy source to the *C-4* Mariner-Class cargo vessel is analyzed in some detail. The results show that nuclear power cannot compete with conventional power plants at this time, at least not on a straight economic basis. However, advances in reactor technology will improve the competitive position of this new energy source.

Other factors, such as weight, space, speed, and range considerations, will influence the application of atomic power for marine purposes, and must be included in any complete evaluation. Military advantages of nuclear power, although very significant, are beyond the scope of this article.

REFERENCES

1. Propulsion Machinery and Auxiliaries on the Mariner. *Marine Engineering and Shipping Review*, New York, N. Y., May 1953, pp. 99–110.

2. Mariners. *The Log*, San Francisco, Calif., March 1953, pp. 44–85.

3. Swords into Plowshares, A Study of Current and Future Developments in Commercial Atomic Power, **The Student Committee on Atomic Energy.** Harvard University Graduate School of Business Administration, Cambridge, Mass., 1951.

4. Economic Selection of Steam Conditions for Merchant Ships, **Douglas G. MacMillan, Mark L. Ireland,** *Transactions*, Society of Naval Architects and Marine Engineers, New York, N. Y., vol. 56, 1948, p. 149.

5. Can Nuclear Power Plants Compete? **Walker L. Cisler.** *Electrical World*, New York, N. Y., August 11, 1952, p. 107.

6. Reports to the U. S. Atomic Energy Commission on Nuclear Power Reactor Technology, May 1953. The United States Government Printing Office, Washington, D. C. (Price 25 cents.)

7. Tables Simplify Comparison of Nuclear Power Feasibility Studies, **John W. Landis.** *Electrical World*, New York, N. Y., November 9, 1953, pp. 24–5.

8. Sourcebook on Atomic Energy (book), **Samuel Glasstone.** D. Van Nostrand Company, Inc., New York, N. Y., p. 391.

9. Basic Problems in Central Station Nuclear Power, **W. H. Zinn.** *Nucleonics*, New York, N. Y., September 1952, pp. 8–14.

Electrostatic Electron Microscope

A new type of electron microscope, capable of magnifying an object 100,000 times, has been given to Stevens Institute of Technology, Hoboken, N. J., by the Farrand Optical Company. The device magnifies a specimen 20,000 times by direct viewing, while photographs of the magnified image can be enlarged up to 100,000 times.

The new machine resembles in appearance a small desk, with a viewing glass and regulating dials on its top. The viewing scope has a small screen similar to that on a television set, which permits the operator to observe the image directly. A permanent record of a specimen can be obtained by photographing it by means of a built-in camera.

Stevens is one of the few colleges with a laboratory where electron microscopy is taught. Occasionally, work is done for commerical organizations who arrange for the laboratory's services.

Field Tests on a 100-Megawatt Rectifier Installation

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THE 100-megawatt rectifier station at the Robert P. Patterson Plant of the Reynolds Metals Company is the largest concentration of d-c power on a single bus in this country. Power for the plant is obtained from 24 double-Y ignitron rectifier assemblies, each rated at 5,208 amperes and 800 volts. In March 1954, an extensive field-test program, involving both load switching and arc backs, was conducted at this rectifier station.

Power interruptions on rectifier installations may occur either because of involuntary loss of a-c power or because of voluntary shutdowns, the latter often resulting from emergency conditions in the cell room. On older installations, where the maximum current is around 60,000 amperes, voluntary load drops are usually made by master-tripping the cathode circuit breakers. Where this practice is followed, the highly-inductive potline causes about half of the normal load current to shift to the last rectifier to clear.[1] If load is dropped by interrupting the a-c circuit with auxiliary power kept on the firing circuits, any anode is free to conduct and the decaying load current can divide between all the rectifiers. For this reason, the latter method was recommended for making voluntary trips at large rectifier stations.[1] The purpose of these tests was to substantiate this practice.

Four load-dropping tests were made. These showed that partial reduction in load by phase delay (control), before tripping the a-c circuit, has negligible effect on the transient currents. Delay is desirable on planned trips, however, to reduce the magnitude of load which is abruptly dropped from the power system. In one test the auxiliary power source was tripped simultaneously with the a-c circuit, a situation which would prevail in case of power failure. None of the tests showed transient cathode currents higher than 2.2 times the current carried at the instant the operation was initiated. On previous tests,[1] where master-tripped cathode breakers were employed, transients roughly four times as high were recorded.

High-speed anode and high-speed cathode circuit breakers are employed to clear arc backs at this plant. Use of high-speed breakers in both circuits differs from the conventional protection system. Most large installations are protected by high-speed anode breakers with current limiting reactors on the a-c side of the rectifier transformer in those cases where the fault current can exceed equipment fault current ratings.

Objectives of the tests were to compare fault currents obtained in the field with calculated values and to observe arc-back phenomena at a large rectifier station. Eight transition arc backs were obtained and oscillograms from one of these are shown in Fig. 1. Magnitudes of fault current taken from curves developed on the analogue computer[2] check values measured on test within 10 per cent, a good check in view of the lack of exact values for all the circuit constants.

When sympathetic arc backs occur on a rectifier, the duration of the fault on the system is increased with corresponding increase in the disruptive effect of fault current stresses. Not a single sympathetic arc back occurred on any of these tests. The controlling factor in the production of sympathetic arc backs is the magnitude of forward-flow current fed into the original arc back by other ignitrons on the same transformer group. Forward-flow currents are kept at a minimum through the use of high-speed anode circuit breakers.

Results of the test show: the best method for making voluntary load interruptions on large rectifier installations is by a-c line circuit breaker operation with auxiliary power maintained on the rectifiers; in case of power failure, high transient currents do not occur, but there is some shifting of currents between parallel rectifiers; the arc-back protection system consisting of high-speed circuit breakers in both the anode and cathode circuits showed excellent interrupting capability; calculated values of fault current obtained from analogue computer studies may be used with confidence; and with the ignitron design and protection system employed at this installation, the data indicate that sympathetic arc backs will not occur.

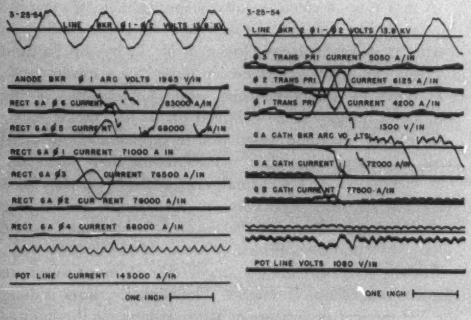
3-25-54
ANODE BKR Ø 1 ARC VOLTS 1965 V/IN
RECT 6A Ø 3 CURRENT 83000 A/IN
RECT 6A Ø 4 CURRENT 68000 A/IN
RECT 6A Ø 1 CURRENT 71000 A IN
RECT 6A Ø 3 CURRENT 76500 A/IN
RECT 6A Ø 2 CURRENT 79000 A/IN
RECT 6A Ø 4 CURRENT 68000 A/IN
POT LINE CURRENT 143000 A/IN
ONE INCH
3-25-54
Ø 3 TRANS PRI CURRENT 5050 A/IN
Ø 2 TRANS PRI CURRENT 6125 A/IN
Ø 1 TRANS PRI CURRENT 4200 A/IN
1500 V/IN
6 A CATH CURRENT 72000 A/IN
6 B CATH CURRENT 77500 A/IN
POT LINE VOLTS 1080 V/IN
ONE INCH

Fig. 1. Arc-back record

REFERENCES

1. Load-Dropping Tests on a Large Ignitron Rectifier Installation, **S. J. Pope, J. K. Dillard, C. R. Marcum.** AIEE *Transactions*, vol. 72, pt. I, 1953, pp. 164–175.

2. Rectifier Arc-Back Study on the Analogue Computer, **J. K. Dillard, C. J. Baldwin, Jr.** AIEE *Transactions*, vol. 73, pt. I, 1954, pp. 198–208.

Digest of paper **55-39**, "Field Tests on a 100-Megawatt Rectifier Installation," recommended by the AIEE Committee on Electronic Power Converters and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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Effect of Synchronous-Machine Transient Rotor Saliency

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In most studies of power system disturbances made on the a-c network analyzer, the transient rotor saliency of the synchronous machines is neglected. The validity of this assumption is well established. However, in some cases it has been desirable to measure the variations in several of the bus voltages during the disturbance. When the bus is electrically near to a synchronous machine (in the limit, when the voltage in question is at the terminals of one of the synchronous machines), the validity of neglecting saliency may be questioned.

The paper presents curves of voltage variation at the terminals of a synchronous machine both including and neglecting machine saliency. From these curves, an estimate of the error involved in particular bases may be obtained.

"Rotor saliency" as used here is a general term meaning that the quadrature-axis (or interpole-axis) reactance is different from the direct-axis (or pole-axis) reactance. This concept can be applied to the subtransient, transient, or steady-state condition. However, the quadrature-axis and direct-axis reactances must be defined under the same conditions. The word "saliency" derives from its usage in the steady state since the difference between quadrature-axis reactance and direct-axis reactance in the steady state usually arises due to the presence of salient poles. During transient or subtransient conditions, the difference in the electric characteristics of the rotor windings in the two axes, rather than the difference in magnetic permeance, causes a difference in the two reactances.

The system analyzed consists of a synchronous machine tied through reactance to an infinite bus. Three initial load conditions on the synchronous machine were considered:

1. Full load, unit terminal voltage, 0.8 power factor.
2. Full load, unit terminal voltage, 1.0 power factor.
3. Zero load, unit terminal voltage, zero current.

The initial tie-line reactance was taken as 0, 0.2, 0.4, and 0.8 per unit on the machine base. The direct-axis reactance of the machine is 0.3 per unit. (This will be interpreted as the transient reactance.) The quadrature-axis reactance of the machine was given three values: 0.3 (no saliency, to correspond to the usual assumption made in transient stability studies), 0.6, and 1.2. These three values of quadrature-axis reactance should cover the range found in most applications. The value of direct-axis transient reactance is larger than may be found at the terminals of a turbine-generator, but is taken as being possibly the most nearly representative value for a range of cases.

From the voltage vector diagram of this system the initial values of system voltage and machine field flux may be determined. Both of these quantities are assumed constant during the subsequent disturbance, and the resulting value of terminal voltage calculated. Two kinds of disturbances are considered:

1. The angle δ of the machine relative to the system is varied, corresponding to a swing of the machine.
2. The system reactance x_2 is varied, corresponding to the switching out or in of some line or other part of the system.

The results are given in the complete paper in the form of 17 figures. A typical example is shown as Fig. 1 of this digest.

It is concluded that it is not possible to dismiss completely the effect of synchronous-machine transient rotor saliency on voltage variations. Saliency may be negligible in some cases, but it is suggested that in general the curves of the paper may be used to help determine whether or not saliency is significant. If it is, then it either can be properly taken into account in the study, or these curves may be of assistance in obtaining estimates of correcting factors. The effect of saliency is most pronounced in those cases where sudden changes in system reactance, as viewed from the machine in question, are involved, as compared to those cases where only angular swings are involved.

The results reported here do not invalidate the usual practice of neglecting synchronous machine transient saliency as far as stability limits are concerned.

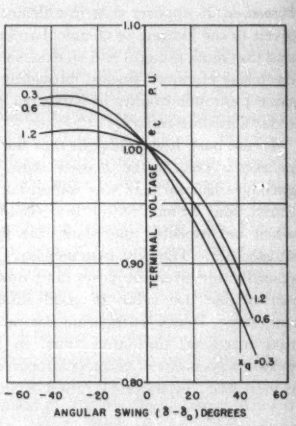

Fig. 1. Effect of synchronous machine transient saliency on variation of terminal voltage with angle

Initial conditions: e_t = 1.0, power factor = 0.8, i = 1.0. x_2 = 0.4 for x_q = 0.3, δ_0 = 34.4°; for x_q = 0.6, δ^0 = 43.3°; for x_q = 1.2, δ_0 = 52.0°

Digest of paper 55-3, "Effect of Synchronous-Machine Rotor Saliency on Changes in Terminal Voltage," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Operations Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Applications and Industry*, 1955.

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Lighting a Modern Refinery Process Unit

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Within the past few years more attention has been paid to increasing and bettering illumination in work areas. While progress has been made in outdoor lighting, there is room for improvement in those exteriors where 24-hour operations need adequate lights. Although this article applies to a refinery, there are ideas applicable to many industries.

IN the years since World War II, much engineering research has been done on the design of proper illumination. Many volumes have been written on the lighting of residences, churches, streets, shop buildings, sports areas, commercial buildings, and manufacturing plants. However, it appears that insufficient attention has been given to the lighting of chemical and refinery process units, and that more thought and analysis should be applied by the electrical engineer toward providing illumination of the same top-notch quality as is seen in every other feature of today's modern refinery.

In the past, it was thought that the cost of lighting was a necessary evil, to be classed with janitor services and garbage disposal. It was something that had to be endured, and as long as the boss could see his way around when he inspected the plant, the lighting was perfectly satisfactory. Happily, management's thinking has changed considerably over the years, and now the people who do not realize the value of good illumination are in the minority. Improved lighting has proved itself in production increases, time after time, in every industry. The worker's accuracy of vision is improved; his speed of vision is increased; his morale is raised because his tasks are made easier and more comfortable; and when the number of footcandles goes up, the number of accidents goes down.

It must be emphasized that the purpose of illumination is *seeing* and a lighting system cannot be designed without a thorough knowledge of the seeing tasks which will be performed. With this in mind, consider a typical process unit, one that might be found in any refinery or chemical plant.

In general, the unit may be divided into several areas, according to the types of seeing tasks to be performed:

Outdoor operating equipment areas.
Ramps and walkways.
Driveways and yard areas.
Control room.

Each of these areas requires a different type and/or level of illumination and must be considered individually when laying out the lighting system.

OUTDOOR OPERATING EQUIPMENT AREAS

THE operating equipment areas require a higher level and better quality of illumination than any other outdoor area within the unit, because in these areas are located the motors, pumps, compressors, turbines, valve manifolds, exchangers, electric switchgear—in short, all the equipment requiring routine operating attention, either visual or manual. The lighting should be adequate not only for routine operation, but also for mechanical and electrical maintenance. Process units operate around the clock, and the chances are better than one in three that mechanical troubles will occur after dark. If emergency lighting must be set up for a vital pump to be put back in service, the cost of the additional time required in down-time of the unit might well pay for the adequate permanent lighting system.

The minimum level of illumination in these equipment areas should be 5 footcandles (ft-c), average, maintained in service. This recommendation, however, is not complete. In such areas as these, what is meant by "average?" In general, the average level is thought to be the sum of a large number of meter readings taken thoughout the areas, divided by the number of readings. By such a definition, then, a 5-ft-c average might be obtained by installing one

Fig. 1. Adequate illumination is obtained in this pumping area for the valves, manifolds, etc. by means of floodlighting. Each portion of the area should be lighted from two directions to minimize harsh shadows

Full text of conference paper CP55-20 presented at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955, and recommended for publication by the AIEE Committee on Petroleum Industry.

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powerful source of light in the middle of the area, yielding, say, 500 ft-c directly under it, and as little as 0.1 ft-c at the edges of the area. Such a system would, of course, be ridiculous. In most equipment areas will be found myriads of overhead piping, stanchions, and other obstructions to a smooth, even distribution of light. Light sources must be located so that dark shadows will not be cast on oil gauges, valve handwheels, or any other piece of equipment which may require attention. See Fig. 1.

The foregoing recommendation can be restated more completely: the number of lumens required to illuminate an equipment area shall be sufficient to provide an average level of 5 ft-c on a horizontal plane considering no obstructions, and the number of luminaires shall be such that no objectionable shadows occur between pumps, behind exchangers, or in any other portion of the area. The utilization of light in these areas is affected to a tremendous extent by the painting of the piping, structures, and mechanical equipment. In locations where surfaces are dark and dirty, a satisfactory lighting system is practically impossible. See Fig. 2.

It is evident from this that the electrical engineer, before beginning his design, must become familiar with the mechanical equipment and piping layouts of the unit, and should have formed a mental picture of the completed installation.

The lighting system usually employed in these areas consists of a number of local fixtures, 100-300 watts, with dome or shallow-bowl reflectors, supported from adjacent structures or from their own conduit, in a gooseneck fashion. It is evident that a large number of such fixtures will be required because of their necessarily low mounting heights if objectionable shadows are to be eliminated.

Consider a different approach to the problem. The sun does an excellent job of lighting most parts of these areas, and from above. If the natural lighting from above during the day is excellent, artificial lighting should be placed up high and illuminate from above at night. In other words, floodlight all possible areas. Of course, there will be many locations where illumination from floodlights is impractical, such as areas under solid roofs, under rows of piping, and between towers. But usually the majority of the areas can be very satisfactorily lighted from several floodlight pole locations.

What are the advantages of floodlighting?

In many cases, the inital cost will be less. This is especially true where the locally mounted fixtures must be explosionproof. The floodlights, being located high and at a distance from the equipment, will probably not be required to be explosionproof.

Maintenance costs will be less. Although the fixtures are located at the tops of poles, they are grouped, and with one trip up each pole, the maintenance man can relamp and clean every fixture in the area. Group lamp replacement here is very desirable. With the fixtures located high and at a distance from the equipment, they will be less likely to collect dirt, grease, and other foreign matter.

The smooth, even distribution of light obtainable from floodlighting is superior to that from the locally mounted fixtures.

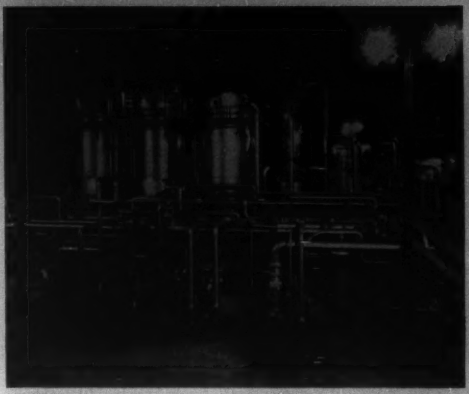

Fig. 2. The operating equipment from above, showing the effect of asphalt spillage on the quality of illumination. This illustrates the fact that it is practically impossible to light properly a dark and dirty surface

To be free from direct glare, the floodlights should be mounted at least 40 feet above the ground, and usually not more than 60 feet. Floodlights should be the heavy-duty type, cast aluminum, to withstand the effects of the corrosive atmospheres found in chemical plants. Five hundred- and 1,000-watt floodlights, with lenses and polished reflectors, have been used successfully, but since the advent of the all-weather reflector lamps, the unenclosed floodlight has been employed with great success. See Fig. 3. Costing roughly 15 per cent of the enclosed fixture, including the lamp, the use of these 500-watt lamps in gasketed cast aluminum lamp holders has effected tremendous savings in the cost of floodlighting. Maintenance costs are reduced because fixture cleaning is eliminated. When lamps are replaced, so also are the lenses and reflectors.

Frequently, in chemical plants, floodlights are supported on tubular steel poles. Such poles can be a hazard to maintenance personnel. It must be remembered that the inside surfaces of these steel tubes are completely inaccessible and cannot be maintained. And evidences of structural weakening of the poles due to corrosion may not be evident from the exterior until actual failure. If steel floodlight towers are to be used, they should be of the exposed-truss type, where the condition of all structural members can be readily inspected.

Where their appearance is not objectionable, creosoted-wood poles may be employed. They are less expensive initially and require less maintenance. Some maintenance people feel that the shock hazard is less with wood poles, since the electrician is not grounded when relamping.

Service to floodlights may be overhead open-wire, but usually it is in underground conduit, because of the interference of the overhead wires with mobile mechanical equipment.

Lighting of higher intensities than those previously recommended may be required for equipment of an especially hazardous nature. Modern chemical processes are calling

for higher temperatures and pressures than were thought possible a few years ago. For example, in a process unit there was a pump which handled 98-per-cent sulphuric acid at several thousand pounds of pressure. A pinhole appeared in the packing which caused a stream of colorless acid the diameter of a pencil lead to spray across a walkway. Fortunately this was discovered before any injury occurred, but it illustrates the need for higher lighting intensities around such hazardous equipment to detect small failures which might result in serious injury.

RAMPS AND WALKWAYS

The lighting for ramps and walkways, particularly elevated walkways, should be designed with the primary thought for the safety of operating personnel. A minimum of 3 ft-c should be maintained in service in these areas. Particular attention should be given to stairways and any change in elevation of a walkway. Locations where tripping hazards exist, such as above-ground piping and curbs, should be provided with extra illumination. Low overhead clearances, both for personnel and mobile mechanical equipment, when not properly lighted is an invitation to an accident. Distinctive painting of such obstructions using contrasting colors, together with the supplementary lighting, greatly reduces the hazards. The cost of this kind of lighting is small compared with the cost of a disabling injury to an employee.

DRIVEWAYS AND YARD AREAS

In most process units, there are spaces between the equipment areas, around the control house, or around the edges of the unit in which no mechanical equipment is located and in which no actual work is performed. The lighting here must not be overlooked. A minimum average of 1 ft-c is recommended for these areas. Although these areas are meant to be kept clear, there may be some equipment or tools left about, and this minimum illumination is necessary for the safety of personnel. In the event of repairs to equipment, these normally clear areas will be used for storage, material handling, and other traffic, and the lighting must be adequate for such cases.

Fig. 3. Five 500-watt reflector lamps are used in this yard on each floodlight pole. Note the 150-watt fixtures near the tops of the towers at heights above the practical range for floodlighting

Floodlighting here is almost mandatory. The low illumination level, the usually large areas, and the need to keep the areas clear, all point toward floodlighting from poles near the edges of the area.

In designing the lighting for areas immediately outside the control room, it should be kept in mind that the pupils of the eyes of a person emerging from the well-lighted interior will require a few moments of adjusting to the lower levels of illumination. Fixtures mounted on the exterior of the control room walls adjacent to the doors will solve the problem.

CONTROL ROOMS

What types of seeing tasks are performed in the control room? In a modern process unit, there are three: reading the instruments, recording the readings, and repairing or adjusting the equipment. The first two tasks dictate a minimum average level of 30 ft-c. The third task determines the quantity of illumination behind the control panel, and this should not be less than 10 ft-c.

Where possible to class the interior of the control room as a general-purpose area, consideration should be given to use of slimline or rapid-start fluorescent lamps. See Fig. 4. The higher illumination level certainly points in that direction, and by their use, a more pleasing, smoother, and cooler installation can be made. The general decor of the interior will determine whether industrial- or commercial-type fixtures will be preferred.

Care must be exercised in locating the fixtures for the illumination of the face of the control board. Shadowless lighting is required to read some of the smaller instruments and gauges. Every instrument has a glass face which presents an excellent mirror surface for reflecting the glare from the overhead light fixtures, and incidence-reflection angles must be checked so that the faces of the instruments will be glare-free. Diffusing glass lenses are desirable on the fixtures illuminating the control board to reduce the reflected brightness. Fixtures with asymmetric lenses have been successfully used for control-board lighting. An excellent method of lighting the board is to tilt the fixtures. Here one entire continuous row of fixtures, usually fluorescent, is mounted at an angle facing the board, and the ceiling is offset by the difference in elevation between the front edge of the fixtures and the back edge.

The rear side of a modern instrument panel is usually a maze of electric conduit and instrument tubing, which makes shadowless lighting almost impossible. Much benefit can be gained, however, by painting the dark surfaces, such as instrument cases and tubing, a dull white. This diffuses and scatters the light into hard-to-reach places.

SPECIAL LIGHTING

There may be some locations which require a special type of lighting other than the general types previously discussed. Instruments such as pressure gauges and temperature and flow recorders may be located in the equipment areas or along walkways and will require supplementary lighting for accurate reading. See Fig. 5. Such lighting might be had from a single fixture with an asymmetric reflector mounted to the front and above the instrument.

Gauge glasses or liquid-level columns, in which the level of a liquid must be observed, also presents a special lighting problem. Lighting fixtures, incandescent or fluorescent, designed especially for illuminating these gauge columns are available and are recommended for this service.

TEMPORARY LIGHTING

An important item in the electrical design of process units, which is often overlooked or underestimated, is adequate facilities for serving temporary lighting for major unit turnarounds. In some of the larger units, 15 or 20 kw in string lights may be required for inspection and maintenance work inside towers, reactors, and other vessels. This load must be served from plug receptacles located throughout the unit, and there are seldom, if ever, too many receptacles to serve all the temporary lighting needed by the maintenance forces. Receptacles should be connected to circuits not serving permanently installed lighting, and individual investigations should be made of each unit to determine the number and capacity required.

EMERGENCY LIGHTING

So if the process unit is completely lighted, there is plenty of light where it is needed, there are no dark shadows, no safety hazards because of improper or insufficient light, and the operators' morale is high. It is 1:00 a.m. when a fault occurs in the primary cable serving the entire unit. Motors and pumps are moaning to a standstill and the operators are stone blind. They find their flashlights and manage to get out to operate the necessary valves to prevent further damage, but their instruments are electrically operated and so are of no use during the time when they are needed most—when the unit is in trouble.

Emergency lighting is important. The cost of lost operating time as well as damage to equipment resulting from power failure may exceed many times the cost of emergency lighting. Many plants which have motor-driven pumps and other equipment have also steam turbine-driven spares, so that the plant may be kept "on stream" in the event of a power failure. Such plants must have emergency lighting. This may be in the form of an auxiliary generator, or a separate primary circuit brought in to an automatic transfer switch. In the event of a loss of power on the main primary circuit, the switch automatically transfers the critical loads to the auxiliary primary circuit. Such loads are the instrument circuits, the lighting for the control board, and possibly one or two lights strategically located outside in the operating areas. In many cases, it is possible to split the lighting load for the entire unit, and permanently connect half to each primary circuit, reserving only the instruments for automatic transfer. Such systems well illustrate the adage: "A stitch in time saves nine."

Fig. 4. Slimline-fluorescent surface-mounted ceiling fixtures illuminate this control room. Flush-mounted fixtures in continuous rows are used for illuminating the control board

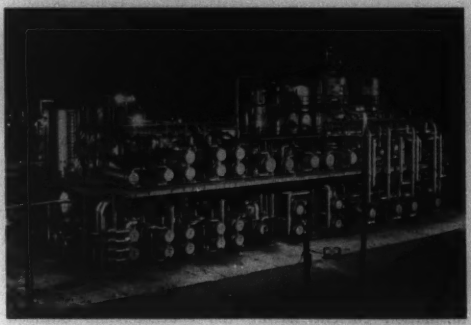

Fig. 5. Although floodlights are used to light this area, the dark places under the platforms show the need for locally mounted fixtures

IMPORTANCE OF PROPER MAINTENANCE

All too often a lighting system is installed and then forgotten about, except to replace lamps when they burn out. Proper results from such a neglected lighting system cannot be expected and full returns from the investment cannot be realized. Globes, reflectors, and lenses should be cleaned every time a fixture is relamped, and in extremely dirty areas, once or twice between each relamping. In plants with a large number of lamps, investigations should be made of the economics of group lamp replacements. Because of the present high labor costs, such replacement programs have resulted in great savings.

Lighting is a production tool in the hands of a human seeing machine, the efficiency of which is greatly influenced by the effectiveness of that tool. Good lighting means greater "P-E-M-S": Production, Efficiency, Morale, and Safety.

Field Current Sources for Electric Defibrillation

P. L. BETZ
MEMBER AIEE

UNDER certain conditions, the heart may lose its rhythmic pumping action and cease the circulation of blood. This situation is known as ventricular fibrillation and may occur during surgical procedures or as a consequence of electric shock. Normal heart action may be restored by passing an electric current of suitable characteristics through the heart. In the operating room, defibrillation is accomplished by applying electrodes to the heart directly and passing a 60-cycle alternating-current of from 1.5 to 2 amperes through the heart (120 to 135 volts). When fibrillation results from an electric shock received under field conditions, electrodes cannot be applied to the heart directly but may be applied to the surface of the body to permit sufficient current to flow through the heart to effect defibrillation. In animal experiments with electrodes at the chest,[1] defibrillation has been accomplished reliably by the use of 60-cycle alternating-current, 480 volts, 15 amperes applied for periods up to about 1 second. Such a current first brings the heart to a standstill; upon interruption of the current, the heart will usually resume its pumping action provided the elapsed time between the onset of fibrillation and the application of defibrillation current is not excessive.

The purpose of this discussion is to outline briefly the results of an investigation of various power sources suitable for use in the field where commercial power may not be available. These sources must be able to provide defibrillation current having the characteristics outlined above. Fig. 1 is a chart indicating the various devices that have been investigated.

Consideration has been given to the use of a turbine-driven generator using a propellant charge. This results in a unit having an estimated weight of about 60 pounds. The development cost would be approximately $20,000 and subsequent unit costs about $1,800.

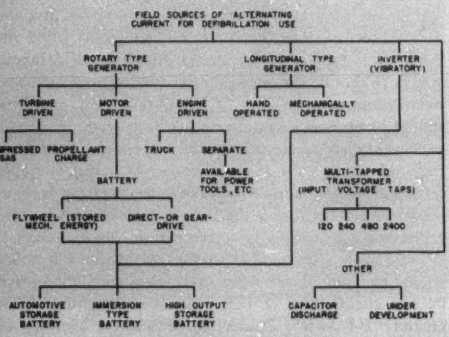

Fig. 1. Current sources for field use

A battery driven motor-generator set has been considered in which use is made of a relatively new type of storage battery that is capable of extremely high discharge rates. This battery employs zinc and silver as the electrode materials and can provide as much as 1,350 amperes for 30 seconds, or 630 amperes for 5 minutes. The weight of the battery together with a suitable motor-generator set would be about 320 pounds and the cost about $3,500.

A generator driven by a separate gasoline engine has been shown to have particular merit. A relatively lightweight a-c generator may be employed together with a suitable gasoline engine. Such a unit on a wheelbarrow-type mounting would weigh about 450 pounds and cost about $700. Its rated output is 15 amperes, 220 volts, 60 cycles, 3-phase. Defibrillation current could be supplied single-phase using a step-up transformer. This unit could be used for routine field operations in addition to being available for defibrillation use. The routine field operations contemplated include the use of power tools, blowers, heaters, lights, and battery charging for radio communication. These uses would increase the reliability of starting the engine for defibrillation use and without routine use, doubt would be entertained as to the ability of a stand-by unit to start promptly when required. Conceivably, the unit might be in operation when needed for defibrillation.

A multitapped transformer might be used as the energy source on circuits up to 2,400 volts. Such a transformer would provide input voltage taps for 120, 240, 480, and 2,400 volts for connection to the circuit causing the shock. The output voltage would be 480 volts and current capability, 15 amperes. A disadvantage is the possible time delay in making connection to the exposed circuit, especially where an overhead line is involved. An advantage is low weight—approximately 50 pounds—and low cost—less than $100. Use of the transformer is based on the premise that shocks obtained from circuits of voltages in excess of 2,400 volts would not produce fibrillation.

The other energy sources indicated in Fig. 1 appear to be less promising than those discussed in the foregoing.

Of the four types of field power supplies discussed, the one that appears to hold the greatest promise is the separate engine-driven generator-set used for routine field operations, as well as being available for defibrillation use.

REFERENCE

1. Electric Defibrillation, **W. B. Kouwenhoven, W. R. Milnor.** AIEE *Transactions*, vol. 74, pt. III, 1955. (Paper No. 55-95).

Digest of paper 55-87, "Field Current Sources for Electric Defibrillation," recommended by the AIEE Committee on Safety and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Difference Equations for Magnetic Amplifiers

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THE analysis of magnetic amplifiers through the use of difference equations will result in a different view of the mechanics of operation of the magnetic amplifier. It shows that all magnetic amplifiers operate upon the same basic principles, and that these basic principles are demonstrated by the operation of the basic half-cycle response magnetic amplifier shown in Fig. 1. The purpose of the analysis presented in this article is only to clarify these basic principles.

To simplify the analysis, the B-H curve of the reactor and the rectifier characteristic are assumed to be of the form shown in Fig. 1. The flux change caused by the control voltage during the control half-cycle is proportional to the average control voltage during this half-cycle. The average output voltage is proportional to the change in the flux during the previous half-cycle, hence it is proportional to the average control voltage. This relation can be expressed by the difference equation

$$E_{out}(n) = \frac{R_L}{R_L+R_w} \frac{NR_x}{N^2R_c+R_x} E_c(n-1)$$

In the above equation, E represents average voltages, averaged over a half-cycle. By taking the Laplace transform of this equation, the transfer function is obtained

$$G(s) = \frac{E_{out}(s)}{E_c(s)} = \frac{R_L}{R_L+R_w} \frac{NR_x}{N^2R_c+R_x} e^{-\frac{\pi}{\omega}s}$$

The above difference equation can also be approximated by a differential equation, and the corresponding approximate transfer function is

$$G(s) = \frac{R_L}{R_L+R_w} \frac{NR_x}{N^2R_c+R_x} \frac{1}{\frac{\pi}{\omega}s+1} = K_p \frac{1}{\tau s+1}$$

In Fig. 2 is shown the parallel self-saturated magnetic amplifier. The circuit consists of two basic magnetic amplifiers, which gate during alternate half-cycles, connected in series-parallel. When reactor I saturates, the voltage across the reactor becomes zero. By the use of superposition, this is equivalent to inserting a voltage in series with the control voltage, equal in magnitude to the reactor voltage and with opposite polarity. The average value of this voltage referred to the control circuit is proportional to the output voltage, and it can be written

$$E_{f1}(n) = \frac{1}{N} \frac{R_L+R_w}{R_L} E_{out}(n)$$

The voltage across the load opposes the supply voltage e_s, and so tends to decrease the amount of reset of reactor II. A voltage in the output circuit can be transferred into the control circuit by multiplying it by the turns-ratio, and the ratio of the control circuit impedance to the output circuit impedance. Thus

$$E_{f2}(n) = \frac{1}{N} \frac{N^2R_c}{R_x} E_{out}(n)$$

The two voltages, E_{f1} and E_{f2}, can be considered in series with the control source, and they are proportional to the output voltage. The feedback gain is defined as the portion of the output voltage that is fed back into the control circuit. From the above equations, the feedback gain becomes

$$K_f = \frac{1}{N}\left[\frac{R_L+R_w}{R_L} + \frac{N^2R_c}{R_x}\right]$$

The difference equation can be written

$$E_{out}(n) = K_pE_c(n-1) + K_pK_fE_{out}(n-1)$$

By following the same procedure as described previously, the approximate transfer function is found to be

$$G(s) = \frac{R_L}{R_w} \frac{R_x}{NR_c} \frac{1}{\frac{\pi}{\omega}\left(1+\frac{R_L}{R_w}\right)\left(1+\frac{R_x}{N^2R_c}\right)s+1}$$

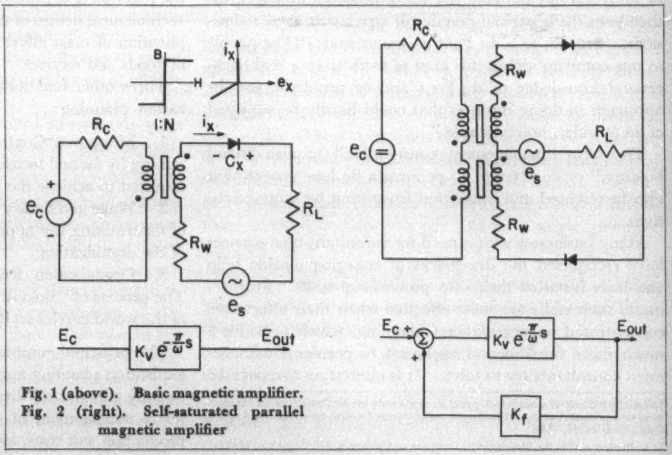

Fig. 1 (above). Basic magnetic amplifier.
Fig. 2 (right). Self-saturated parallel magnetic amplifier

Digest of paper 54-509, "Analysis of Magnetic Amplifiers by the Use of Difference Equations," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-15, 1954. Published in AIEE *Transactions*, vol. 73, pt. I, 1954, (Jan. 1955 section), pp. 700-11.

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Organization Planning—The Hard Work and Common Sense Approach

L. L. PURKEY

The Department on Organization in an oil company was created to perform the function of organization planning. Surveys conducted by this department have resulted in many significant organizational improvements throughout the company.

A RECENT ISSUE of a national magazine contained an article about management's dependence upon professional management consultants' services. It was of special interest to learn that, according to the Association of Consulting Management Engineers, there are now 1,900 consultant firms operating in principal cities. These firms employ 44,000 persons and collected 426-million dollars last year in fees.

Management consultants' services are applied to the solution of their clients' problems by three principal routes:

1. By the installation of new methods, machines, and procedures.
2. By personnel changes based upon appraisal and psychological counseling techniques.
3. By striving to be the President's "right hand man."

The record of services provided by management consultants' is impressive and it is estimated that 90 per cent of their work satisfies their clients. However, this degree of satisfaction probably stems from the practice of catering to the whims and ideas of the client rather than prescribing sometimes painful but badly needed medicine.

There are perhaps two serious drawbacks to dependence on outside professional services. First, when a consultant does the work, he, and not the company, gets the experience of studying and thinking out the problems; management then loses the beneficial practice of arriving at its own decisions. Second, as a du Pont executive said: "The people in our company doing this kind of work have a real background knowledge of du Pont and its problems and its approach to doing business that could hardly be expected of an outsider, however able."

The term "management consultation" implies "hand holding," or an attempt to perform a de luxe service that may be resented and considered frustrating by most executives.

Many businesses with a need for consultant-type services have recognized the drawbacks of engaging outside help and have installed their own professional staffs. Furthermore, such staffs are most effective when their efforts are concentrated on organization planning, which provides a much more fundamental approach to problems management consultants try to solve. It is interesting to report the views and experience of the National Industrial Conference Board which sits at the cross-roads of a constant flow and exchange of information among thousands of companies. This Board reports that there is no subject or function in which members of top management suddenly have taken such a deep and widespread interest as in organization planning. This interest bears no resemblance to a "management fad" or a "gimmick." It stems from the recognition of a real need by both large- and medium-sized companies.

The Board further reports that it is having difficulty in keeping up with the demand for information on the subject of organization planning despite the addition to its staff of highly qualified personnel. Another indication of the rapidity and scope of growth in the subject is the fact that the Board has appointed an Advisory Council on Organization Planning with members selected from business and industry. This Council was formed quietly with no ballyhoo or publicity, yet numerous requests are received from companies both in the United States and Canada about how to obtain memberships.

ORGANIZATION PLANNING IN AN OIL COMPANY

THE Department on Organization in the Standard Oil Company of California was created in 1931 to perform the function of organization planning. It is defined as: the architectural design of the organization structure for the application of mass effort to the production and distribution of goods and services.

Three other functions are inseparably related to organization planning:

1. Manpower Control, defined as: The means of determining by factual measurement the size of the organization required to achieve the objectives of the company.
2. Wage and Salary Evaluation, defined as: The means of determining the appropriate price for labor in all levels of the organization.
3. Organization Research and Training, defined as: The process of "looking over the fence" to see how the rest of the world carries on its activities.

The principal emphasis in this article will be on the organization planning and manpower control functions. To be fully effective all these functions must provide tools useful to management in its never-ending efforts to increase production, cut costs, and improve profits.

Essentially full text of a conference paper recommended by the Committee on Management and presented at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954.

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All too frequently the prevailing concept of organization planning involves nothing more than preparation of a symmetrical organization chart and a gold-plated statement of policy. This reflects someone's dream about how the enterprise should function if all its members conformed to an unrealistic pattern of perfection.

The real reason for organization planning is to place the proper kind and amount of responsibility and accountability in the hands of people required to operate or carry on an activity. There is no magic formula in the process. It usually involves "sweating out" the answer by the application of tested principles to the carefully gathered facts being performed, or about to be performed, and the people doing it or about to do it. The end result is not to be measured by the artistry and symmetry of an organization chart. An organization chart is simply a sketch or a road map to record a working arrangement between individuals. The real measure of successful organization planning is how well the organization functions with how few people.

Perhaps an electrical engineer might think of the organization chart as a wiring diagram without values assigned to the various resistors, conductors, amplifiers, etc. This organization diagram is transformed from a piece of paper to a live apparatus by filling the jobs represented by little squares with people—some of whom may be resistors, some conductors, some amplifiers, and some just plain short circuits. These people must then be given objectives and rules of conduct to co-ordinate their actions.

In the Standard Oil Company of California a tool called the "Management Guide" supplies the rules of conduct. This guide is a special form of organization manual. However, it has this important difference from most organization manuals—it is entirely free from procedural detail and is written in a manner to suggest constructive thought and action, rather than to give a mandate. It is intended to supply specific answers to some questions which have troubled management since the first management team was organized.

Many of you have asked yourselves these questions:

1. What is my basic function?
2. What are my principal responsibilities?
3. What are the outer limits of my authority to make decisions and take action without encroaching on another's position?
4. What relationships am I expected to maintain with my superiors, with my subordinates, and with my co-ordinates?

By providing answers to such questions, the Management Guide found increasing and enthusiastic acceptance throughout the company as an understandable bill of rights for management and supervisors.

This lends support to the proposition that organization planning, to be useful and effective, cannot stop at the graphic chart of the outline of the plan. The plan is incomplete unless it includes the definition of functions, and their allocation to the proper organizational component.

This process adds life and flesh to the skeleton of the plan. To produce a complete and articulated body and to check its conformation, responsibility, authority, and accountability also must be defined and allocated. In this process the relative importance or value of functions must be considered, and proportioned emphasis placed on each as appropriate. Otherwise, the whole machine may be out-of-balance as an eccentric wheel. Even so, the job of organization planning does not end with balancing the wheel, for organization is a live and changing thing.

Dudley Phelps, in his book on sales management, has made the observation that changes in organizational structure from time to time are necessary and should not be avoided. An organization plan is the reflection of an operating task, and if the task changes materially, so should the organization. If investigation indicates the need for a change, it should be made with little hesitancy, for the old organization has probably become outmoded in view of new demands made upon it. It is a common error to become too conservative about organizational changes and not recognize their need. At other times an automatic adjustment to new conditions is somehow expected to take place by itself.

There may be personnel problems involved because a change in organization means a disturbance to existing relationships between members of a group. Responsibilities and authority are shifted among people, perhaps to the disadvantage of some, and to the advantage of others. Because of this, changes should not be made without proper investigation by a qualified staff which is permitted to develop the facts in a thoroughly objective way. This suggests the desirability of periodic review to determine whether the organization is doing an effective job and, if not, whether the reasons for failure are those of structure, ineffective co-ordination, poor morale, or incompetent personnel.

It was in recognition of this never-ending need for improvement within the past 12 months in this company, that an extensive survey of transportation and distribution of petroleum in all of its various forms and ramifications was authorized. The study led to an important change by the creation of a new major organization unit on supply and transportation. With the assistance of members of line management from the six departments under review, a new and better plan to meet the company's needs for management and co-ordination was developed and gained approval: 1. marine, motor, rail, and air transportation; 2. the distribution of products from refineries; and 3. the purchasing of crude oil to supplement production from its own wells. These operations had historically been carried on under separately managed departments with only limited and informal co-ordination. Demands for increased movement of petroleum products and better control over inventories made it necessary to place under a single executive the direction of some 2,000 employees who are engaged in:

1. The operation of 28 company-owned tankships, barges, and towboats, and the scheduling of seven time-chartered tankships.
2. The operation and maintenance of 3,500 motor vehicles.
3. The purchase of 30-million dollars' worth of rail, highway, and air transportation per year from commercial carriers.

4. The purchase of 170-million dollars of crude oil from other producers per year.

The total annual expenditures of this new organization unit is 250-million dollars per year. It required one year for a team of organization specialists to develop the multitude of facts which led to the decision to make the change. The survey team was actively assisted by men assigned to it from the departments under review. Thus, benefits of inside experience, as well as an outside objective point of view, was received. Through this collaborative effort, the impact of the changes in working assignments, relationships, and authority, which are an inescapable part of major reorganizations, was minimized. Last, but not least, in the new organization men are available to provide the answers to the many questions which cannot possibly be anticipated for inclusion in the written plan, the organization charts and organization manual.

MANPOWER CONTROLS

Of equal importance to top executives are the development and use of adequate manpower controls. By these are meant the measurement of labor's productivity—all labor including management, staff, supervisory, and the daily rate employees.

During the past 20 years industrial management has almost completely lost control over wage setting or the determination of the price at which labor should be paid. Under the pressure of labor union negotiations with the steel, coal, and automobile industries the pattern of wage increases is fixed nationally at the bargaining table. Within 30 days after the conclusion of negotiations between the powerful unions and the major industrial groups, other members of industry follow with almost identical wage increases. The collateral pressure of wage increases in daily rates must of necessity be projected into the salaries of non-union employees, including management. It is no overstatement to say that, as a result, at least 70 per cent of all wage and salary rates are set under conditions over which industrial management has no control.

Loss of control over the price at which labor is paid makes improvement in productivity a must. It is a common mistake to believe that labor has failed to see the advantages of management's efforts to stabilize employment through sound planning and increased productivity.

As early as 1925 the American Federation of Labor said:

"We hold that the best interests of wage earners, as well as the whole social group, are served by increasing production in quality as well as quantity and by the high wage standards which assure sustained purchasing power to the workers, and therefore higher national standards for the environment in which they live, and the means to enjoy cultural opportunities."

The difficulty lies in measuring labor's productivity, as used in its broad sense, as it applies to all labor, including management, staff, supervisory, clerical, accounting, technical, and the daily rate employees—commonly referred to as the "represented" groups.

Quite apart from the profit incentive to control costs through performance standards designed to measure the productivity of labor, there is another equally valid reason to maintain continuous control over employment. This refers to the vital need to stabilize employment and to avoid the devastating influence of mass hiring and mass firing of workers because of a lack of planning and work measurement. Under adequate controls and the use of work measurement standards, attrition through resignation, retirements, and normal severances, has made mass hiring and firing unnecessary except for the war period in the company. This is an important point to get across to employees in the maintenance of good industrial relationships.

CONTROL OF MANPOWER

Manpower controls are established and maintained in the Standard Oil Company of California through one of two methods: by organization and manpower surveys which encompass management, supervisors, staff, clerical, and accounting; or through time and motion studies. Organization and manpower studies are undertaken on a project basis usually at the request of a vice-president or department head and with approval of the president.

Each project undertaken is covered by a written agreement called a project work order, which states the objective of the survey and the means of its accomplishment. Staff assistance is borrowed from the organization unit under survey and added to the survey team which is directed by a senior member of the organization planning group.

The results of the survey are made known to line management as rapidly as possible and divergent opinions are reconciled. Finally, the organization changes and manpower tables are agreed upon and are then translated into controls such as basic organizations or work measurement standards where the volume of production varies. In actual practice the process is not as simple as it sounds as there is a lot of wear and tear involved in gaining line management's acceptance of some changes in either organization or manpower. The most potent influence behind this activity is the chief executive's interest in and support of the organization planning effort.

As a follow-up on manpower control, line management is required to report currently to the top executives all significant changes in manpower, either increases or decreases, and the reasons therefore. The president looks to the Department on Organization to co-ordinate and confirm these reports and to make spot checks as necessary to make certain that every step has been taken to maintain and improve the productivity of labor. The theory in this company is that a comfortable organization is never an economical one. By this is meant that, as far as practical, every employee should have a substantial backlog of work at all times.

MEASURING EFFECTIVENESS

Annually, as part of the follow-up on manpower controls, an appraisal is made of their effectiveness in each organization component of the company. This appraisal takes the form of an audit by organization specialists who sample check the application of standards and other controls to confirm their use and validity.

This appraisal of manpower controls is conducted under general principles:

1. Effective control of manpower is an inherent responsibility of the respective department and subsidiary heads.

2. Department and subsidiary organization planning staffs are responsible for:

A. Obtaining maximum interest and participation in the project on the part of departmental and subsidiary personnel.

B. Reporting the number of jobs under recognized controls, broken down into designated categories.

C. Test-checking and observing the application of controls.

D. Advising, counseling, and guiding management and its staff assistants on manpower control practices.

E. Clearing findings, recommendations, and program proposals with the respective levels of department and subsidiary management.

3. All possible agreement with respective department and subsidiary heads is reached before a summarized year-end report is submitted to the president and other executives.

In the report, manpower is divided into groups whose jobs are controlled:

1. *By Performance Standards:* Defined as a measurement of the output which an average qualified employee or group of employees can accomplish in a given period of time, and by which productivity is gauged and the numerical strength of the organization increased or decreased in direct ratio to varying workloads. Examples of work controlled by performance standards are:

Typists. Under standards based upon number of pages of standard copy typing turned out per working day.

Barrel Fillers in a Refinery. Under standards based upon number of containers of a given type which can be filled per hour or per day.

Mechanics (Valve Repairmen). Under standards based upon the number of valves or valve parts of a given size and type which can be subjected to a specific reclamation process per hour or per day.

Oil Well Drilling Crews. Under standards based on drilling plans and estimates compiled for each individual well; charting of anticipated progress; and daily plotting and comparison of actual progress against estimated progress and against accomplishments on the fastest drilled well in the field.

2. *By Attendance Standards:* Defined as a measurement of the numerical strength of the organization required to be present for supervision, to make operating adjustments, to meet emergencies, or to protect property, and by which the numerical strength of the organization is increased or decreased in direct ratio to the need for coverage. Examples of work controlled by attendance standards are:

Operators at Pumping Stations. Under a standard based upon the necessity for the continuous presence of a man to start, stop, and maintain pumps and switch lines.

Operators at Gasoline Plants. Under a standard based upon the necessity for continuous presence of qualified operators to make adjustments; to observe pressures, temperatures, and run quantities; and to be available to shut down or switch lines in the event of an emergency.

Gate Guards at Refineries. Under a standard based upon coverage required at principal gates to ensure that no unauthorized person gains admittance to the refinery.

Tankship Crews. Under a standard based upon workload and watch coverage necessitated by operating requirements and confirmed by specifications in the vessel's inspection certificate.

3. *By Organization and Manpower Surveys:* Covering activities or jobs established or continued as the results of: A. Department on Organization studies, or B. internal studies, conducted by management and staff. Examples: surveys directed toward the analysis and appraisal of organization, functions, methods, workloads, and manpower requirements such as:

The study of pipe line and refinery operations at Salt Lake City, requested by our management there and conducted by the Department on Organization.

The Purchase and Stores Department study of purchasing and auxiliary activities conducted by department management and staff.

The Advertising Department study of organization, methods, and manpower arranged by department manager and conducted jointly by department's staff and Department on Organization.

The Manufacturing Department study of maintenance activities by department management and staff directed toward establishment of maintenance planning systems, budgetary arrangements for maintenance labor, and control on labor utilization during maintenance projects.

4. *By Policy:* Activities or jobs established, continued, or verified as a result of: A. Decision of a company officer or department head, or by the president of a subsidiary, or B. Governmental regulations, but not otherwise necessary. Example: Many of such positions carried under the policy category are filled by employees of advanced years and nearing retirement, or with impaired health. This is a reflection of a generous attitude on the part of the company but it is applied judiciously. It is considered desirable to know at all times how many people are maintained on the payroll under this policy.

5. *All Others:* Situations not meeting the conditions outlined for the foregoing categories of control; specifically those jobs or positions which cannot be logically considered to have been established or verified as a result of "performance standards," "attendance standards," "surveys," or "policies."

The result of the appraisal of manpower controls is reported to the president, the vice-presidents and to general management or department heads with appropriate comments upon the accomplishments made during the year.

Line management is encouraged and assisted in formulating its manpower control program for the ensuing year. This is aimed at achieving further improvements in the productivity of labor. By this means there is a con-

tinuity of interest in the program from year to year which is an important item in top management's responsibilities.

On the basis of the 1953 year-end appraisal of manpower controls the report to the president and other executives showed that the following situation had been attained:

Of a total payroll of 32,000 employees receiving 172-million dollars per year:

44 per cent were working and being controlled under valid performance standards.
24 per cent were working and being controlled under valid attendance standards.
27 per cent had been subjected to recent organization and manpower surveys.
0.6 per cent were employed in jobs established by policy.
4 per cent were employed in work which had not been adequately measured.

This does not mean that the work of 4 per cent of the employees is unnecessary and that the employees so classified should be severed. It simply means that there had been insufficient opportunity to measure their performance and set adequate standards.

DECENTRALIZING ACTIVITIES

The question is frequently asked about the concentration of staff effort on organization planning and manpower control. It is a serious mistake for top executives to permit line management to avoid its responsibilities for maintenance of sound organization plans and controls over manpower. It is an equally serious matter for the activity to become a contest between line and staff management with one side trying to cover up defections and extravagance and the other side equally zealous about exposing them. Such relationships always produce bad feeling and reduce the benefits of a very necessary control. This is reminiscent of an illustration of line and staff relationships, wherein a staff manager tells the line manager what to do and the line manager tells the staff manager where to go!

In order to prevent such developments, those in the Department on Organization have always promoted the idea that line management should have its own group of organization specialists which is called the "Organization and Cost Control" staff. As a matter of fact, these staff agencies were created as a regular part of the organization surveys and have trained and supplied the personnel to man them. In all major operating departments and subsidiary companies there are organization and cost control groups for line management.

This provides an ideal working arrangement and permits the free exchange of personnel either on a loan basis or by permanent transfer. As mentioned earlier in the review of supply and transportation, when a major organization survey is undertaken, a requisition is made immediately for men from the staff of line management to assist on the project. When the project is completed, the borrowed members of the survey team are returned to their regular assignments in the departments from which their services were requisitioned. Of the total number of men engaged in organization and cost control at Standard of California, 155 are on the staff of operating departments and subsidiary companies while only 32 are in the central Department on Organization which reports to the president.

The recital of these facts should have made a good case for the policy of decentralization.

WAGE AND SALARY EVALUATION

Many have, no doubt, wondered what mysterious process occurs to determine the amount of their own salary and those of their co-workers. This process is an extremely important one as it is very closely related to organization planning. In the process of working out organization changes, jobs are constantly being formed or reformed—duties are being added or taken away from individual positions. This has a direct effect upon the value of the job for salary administration. It is this company's policy to make salary administration plans thoroughly responsive to organization changes at all times. For this reason the Department on Organization develops and maintains sound and uniform wage and salary standards for company-wide application by line management to jobs paying all the way from $200 a month to $3,000 a month.

Guidance is provided to members of management throughout the company, and approved wage and salary programs are co-ordinated with the objective of providing equitable pay, fully commensurate with value received. Periodically, an appraisal is made of departmental wage and salary administration, including the confirmation of the relative value of various jobs. Comparisons of the company's wage and salary practices are made frequently with those of other petroleum companies and periodically with local industries and industry in general. Policies and procedures pertaining to the development and preparation of job descriptions originate within the Department on Organization and are the basis for guidance on these subjects to departmental management. The Department on Organization serves as a research and fact-finding agency for management of the company on all wage and salary matters, and renders consulting service on these subjects to the various company units.

It must be acknowledged, however, that positive control can be exercised only over salaries for people not represented by unions. These comprise only 30 per cent of a payroll covering 32,000 employees and totaling $172,000,000 per year. Wage rates are determined at the bargaining table.

ORGANIZATION RESEARCH AND TRAINING

The fourth and final function of the Department on Organization is organization research and training. There are two kindred processes involved in this item. The first is the process of "looking over the fence" to see what is going on in the business neighborhood; the other is to train people to be able to carry on in the other aspects of organization planning.

Since all live in a business community of aggressive competition, it is imperative that all must know what is going on around them. It is by "organization research" that changes in the atmosphere of business and competititon can be discovered and taken into account, and thus changes

in organization, manpower and cost control methods, and wage and salary administration can be recommended to keep the company "in the economic race with competition." This is the process by which this company is kept geared to the dynamic changes of the economy.

RESULTS OF ORGANIZATION PLANNING

For any medium- or large-sized industrial firm desiring to accomplish real economies in the operating costs of its business on a continuing basis, it is recommended that it provide itself with a suitable high-level staff agency established to serve management not only on organization planning, but also on the inseparable functions of manpower, methods, and cost control wherein the real pay-off exists. In addition, there are many advantages to the assignment of wage and salary administration to such an agency, as well as the function of carrying on organization research and training. To be most effective, such an agency would, of necessity, have to be an internal working unit of the company. The overwhelming difficulties an outside management consultant would face in attempting to do the same job can now be seen.

That such an internal staff agency can pay is shown by a recent research project by this company's department on employment trends in the postwar period. The study embraced 22 major industrial companies employing a total of 250,000 people. During the 6-year period from the end of 1947 to 1953, the clerical and accounting employees in these companies increased 25 per cent; operating, mechanical, and custodial employees increased 4 per cent; management, supervisory and staff employees increased 30 per cent; total employment increased 13 per cent. The disproportionate growth between clerical workers and production workers suggests a fertile field for study leading to economies.

It was in recognition of the facts disclosed by the research study that the book "More Profit-Less Paper" was published in July 1953. This publication has had a very gratifying acceptance. In all, requests have been received for 3,600 copies from various parts of the United States and many foreign countries.

The degree to which a business survives the mounting costs of higher and higher remuneration for fewer and fewer hours of work will be measured by the success it achieves on a continuing basis in attaining improved productivity for every dollar expended for labor. The free enterprise system and rising standard of living can be sustained in no other way.

A New System of Logarithmic Units

R. V. L. HARTLEY

As the scientific field expands, especially that of electrical engineering mathematics, the number of specialized logarithms in use has been increasing. How should they be labeled? How should their magnitude be expressed? Here is one answer.

AN INDIAN, when asked, "What do you call your horse?" replied "No call'em, use'm all the time." For a long while that was much the attitude of the calculator toward his logarithms. It may work all right when there is only one horse involved, but the number of specialized logarithms in use has been steadily increasing and a demand has arisen for a convenient and systematic way of distinguishing them and expressing their magnitudes. Various units, such as the octave and the decibel, have already come into use, each in connection with a particular physical quantity, and each having its own magnitude and name. Each, in its own field, satisfies the requirement of convenience. In fact it is this very convenience that has led to confusion, through the use of a unit in a field to which it does not apply, because no convenient unit is available in the second field. This is where the demand for a systematic treatment enters.

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Such a treatment has been proposed in the form of a family of units, all of which have a common surname which indicates that they are logarithms of the same particular magnitude. Each has its own given name, which identifies the kind of quantity with which it is used. Each of the existing units may then be thought of as having a given name only. The diversity of their magnitudes places them in separate families, each of which is related to the proposed one, in this case quantitatively through their relative magnitudes. One of them turns out to be a member of the new family.

Before attempting to trace these interfamily relationships, it is well to have in mind what considerations enter into the choice of a unit of logarithm. One of these is convenience in computations. This is generally most fully satisfied when the base used is ten. In connection with certain problems associated with the solutions of differential equations, such as those of wave motion, the

Napierian base e is found preferable. This suggests the desirability of choosing the unit in such a way as to leave the user free to choose that base which best fits his needs.

Other considerations arise out of the use of logarithms which are specially related to particular physical quantities. The octave, which measures the logarithm of the frequency of a musical note, has the unique property that any two notes whose logarithms differ by one octave are in consonance with each other. This is one example of a group of quantities which are involved in sensory phenomena, for which equal steps of the logarithm correspond to equal sensory changes. The decibel was so chosen as to be approximately the equivalent of the "mile of standard cable" at 800 cycles, a convenient size for the unit.

UNIT DEFINED

How then is the unit to be defined to meet both these needs? The solution lies in the concept of primary and secondary units. If an arbitrary base a is chosen, the logarithm of any number x will have a particular numerical value given by $\log_a x$. If this is regarded as the ratio of it to the unit logarithm, the magnitude of the latter must be unity and so the unit logarithm is $\log_a a$. This is a primary unit for this system, just as the meter bar is a primary unit in a system in which the length of the meter bar is unity. However, a length may be expressed in terms of a secondary unit such as the foot. While this may be a primary unit, and have magnitude unity in a system based on a standard foot, in the metric system it has a magnitude equal to the ratio of the lengths of the foot and meter bars. To arrive at a secondary unit for logarithms to the base a, choose an arbitrary number r and take $\log_a r$ as the secondary unit. Its magnitude is then

$$\frac{\log_a r}{\log_a a}=\log_a r$$

Its magnitude is, of course, unity in a system of logarithms to the base r, where it is a primary unit.

If now $\log_a x$ is expressed in terms of this secondary unit, the number of units will be

$$N=\frac{\log_a x}{\log_a r}=\log_r x$$

which is independent of a, and depends only on x and the number chosen to determine the secondary unit. Hence if a secondary unit of this type is chosen as the unit, both purposes are accomplished. The base is left optional while it is assured that a change of one unit in the logarithm corresponds to the number being changed in an arbitrarily chosen ratio.

Returning then to the interrelation of the units, the family to which a particular unit belongs is determined by the value of r which defines it. Once a number has been selected for this purpose it may be thought of as a standard number and its logarithm as one which has been standardized as a unit.

THE FAMILY OF UNITS

The proposed family of units may be described by saying that the standard number which determines their common magnitude is $10^{0.1}$ and so the magnitude of the unit in any system of logarithms to the arbitrary base a is $\log_a 10^{0.1}$. The number of units corresponding to a number x is $10 \log_{10} x$. Since no family name has been agreed upon as yet, an attempt is made to avoid prejudicing this choice by using here the accurately descriptive but entirely impractical designation (log $10^{0.1}$).

While x has been referred to so far merely as a number, in most practical cases it is associated with particular quantities which may or may not have physical dimensions. It may be the ratio of any two values of the quantity and so represents their relative magnitude. It may be the ratio of one value of the quantity to another which has been chosen as a reference value and may be a primary or secondary unit of the quantity. It then represents the numerical part of the absolute value of the quantity expressed in terms of the reference value. The absolute value of the quantity is then x times the reference quantity, which may be represented formally by the indicated product of its magnitude and its dimension. The logarithm of the absolute value of the first quantity may be thought of as being the sum of $\log x$ and the logarithm of the reference quantity, which in turn is formally the sum of the logarithm of its numerical magnitude and the indicated logarithm of its dimension. Thus, in terms of the meter as the primary unit of length, the logarithm of a length of 5 km would be $\log 5+\log 1000+\log L$.

In using the proposed unit of logarithm, it is desirable to be able to indicate the quantity with which x is associated and the nature of the relationship. In the case of the decibel, as originally defined, the name itself specified that the quantity is power. When used alone, x is understood to represent merely relative magnitude. Where a reference power is involved, such as 1 milliwatt, it is indicated by saying decibels relative to 1 milliwatt, and the unit is written as dbm. This method is redundant in that the nature of the quantity, power, is indicated by the name of the unit of logarithm and again by that of the unit of the quantity.

This suggests that, in assigning first names to the proposed units, both the nature of the quantity and the relationship will be adequately specified if the name of the quantity where x is a relative magnitude is taken and that of the reference value or unit when it is the numerical part of the absolute magnitude as expressed in terms of the reference. A "length (log $10^{0.1}$)" would then be the logarithm of the ratio of two lengths and a "centimeter (log $10^{0.1}$)" would be the logarithm of an absolute length expressed in centimeters. The absolute value of a length of 5 cm could be expressed in terms of the meter as a primary unit as (10 log $5-20$) meter (log $10^{0.1}$). The dimension length is here contained in the term "meter" and its logarithm need be introduced only for purposes of dimensional analysis. Logarithms of dimensions then add just as they multiply in the ordinary analysis.

Let us see now how the new family fits into the clan of existing units. Here the patriarch is the stellar magnitude which, in its less precise form, goes back to Ptolemy. It is a unit for measuring the logarithm of the absolute value of the apparent brightness of a star. It belongs to the

family for which r is $10^{0.2}$ and so its magnitude is 4 (log $10^{0.1}$). The reference brightness was so chosen as to make a stellar magnitude of one correspond to the average brightness of a chosen group of "first magnitude stars." The decibel, as originally defined, and the dbm, being respectively a power (log $10^{0.1}$) and a milliwatt (log $10^{0.1}$), are members of the new family. The bel belongs to the closely related family for which r is 10, and so might be regarded as a cousin. The brothers, the octave and the bit, belong in the family for which r is 2. If we were to give these the surname (log 2), the octave would be a frequency (log 2) and the bit a possibility (log 2).

The so-called "voltage db" and similar units, for which the associated quantity varies as the square root of a power in some cases but not in others, call for special attention. The use of the term "decibel" in connection with a quantity other than power is a violation of the original definition of the decibel. It has, however, become so general that it may have to be lived with, at least in the foreseeable future. Regarded as a unit of logarithm of voltage ratio, this unit belongs in the family for which r is $10^{0.05}$. Considered as a secondary unit in the family for which r is $10^{0.1}$, its magnitude is one-half. One so-called "voltage db" is therefore equal to one-half of a voltage (log $10^{0.1}$). In those cases where the power does not vary as the square of the voltage, there is no definite relation between the number of true db, or power (log $10^{0.1}$) and the number of so-called "voltage db." In those where it does, a change of one so-called "voltage db" corresponds to a change of one true db or one power (log $10^{0.1}$). A change of one voltage (log $10^{0.1}$) corresponds to a change of 2 true db.

USE OF UNITS

Having gone to the trouble of setting up this new family of units, one may well ask for what they can be used. A partial answer is to be found in the list of quantities for the measurement of the logarithm of which the decibel has been used or proposed. Those of the general type of a voltage, as discussed previously, include the voltage or current gain of an amplifier, the voltage level along a system, the step-up of a transformer, the standing-wave-ratio of a waveguide, and the loop gain of a servo system. The list also includes quantities which have no relation to power such as frequency, time, and impedance. An interesting combination of the two types occurs in the design of servos, where the relation between alternating voltage across a capacitance and frequency is expressed as approximately 6 db per octave. If the logarithms of voltage and frequency were expressed in voltage and frequency units of the same family, the relation would be exactly one per one.

The logarithms of the ratios of other specific quantities have been used without assigning names to their units. In photography the density of a film is the logarithm of the reciprocal of the transparency. The logarithm of the exposure is widely used and referred to as log E. The logarithm of the photometric magnitude is a familiar but unnamed logarithm. Any of these could be expressed in the proposed unit.

More generally, wherever the significantly different values of a variable form a geometrical, rather than arithmetical progression, its logarithm provides a convenient description of its behavior and a corresponding unit of logarithm can be used to advantage. One such case is the estimation of the best curve to represent a set of experimental data. This can sometimes be done better by insuring an even distribution of the errors with respect to the values of the logarithm of the variable than to those of the variable itself.

NAMING UNIT IS A PROBLEM

As stated previously, no name has been agreed upon for (log $10^{0.1}$). The two which have received most favorable consideration are "logit," abbreviated lgt, and "decilog," dg. There have also been proposed "brigg," bg; "decibrigg," dg; "ralog," rg; and "decomlog," dl. From the purely theoretical viewpoint there are certain objections which apply more or less to all of these. Since the proposed units form only one of the possible families, and it may be desirable in the future to assign a name to some other family, it does not seem wise to appropriate the whole general connotation of a unit of logarithm for this particular family. This would apply most directly to "logit" and "ralog" which suggest nothing as to size. The terms "brigg," "decibrigg," and "decomlog," while they have some quantitative connotation, convey the impression that it is the size of the logarithmic base that determines the unit. While the term "decilog" may suggest that the unit is a tenth of a logarithm, it gives no idea of the size of that logarithm, unless log is taken to be associated with the base ten, which the unit is not. What is wanted is a name which suggests both the logarithmic nature of the unit and the standard number of which it is the logarithm. This author has not been able to find one; if one were found, it would have to meet those practical requirements which are finally controlling.

Another theoretical objection may or may not be worth considering. The standard number which determines the unit, being irrational, cannot be stated exactly. This condition could be avoided by doing what was done in the case of the bel. Ten would be taken as the standard number, and "log," or some more quantitatively descriptive term, as the family name of the unit. The proposed unit would then be a secondary unit called a "decilog."

Radiation Makes Plastic Glasslike

Polyethylene, which is made from oil-derived chemicals, now is on the market in dozens of useful products from squeeze bottles to garment bags. If experiments prove successful, it may soon be exposed to radiation which will give it new possibilities, some of them seemingly fantastic. Polyethylene plastic normally is white, waxlike, and easily melted. After a small dose of radiation, it will retain its strength and elasticity even at high temperatures. Further irradiation makes it stiff and glasslike. New possibilities may someday include cellophane-like houses.

Additions to Z-Transformation Theory

G. V. LAGO
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One of the most powerful mathematical methods for analysis of sampled-data systems is known as the z-transformation method. The z-transform is obtained by substituting z for e^{st} in the Laplace transform of the sequence of samples. $C(z)$ is obtained in closed form with the aid of Table I.

The present z-transformation theory is in its infancy and as additions to this theory are developed, it will become an even more powerful tool for analysis and design of sampled-data systems. One such technique that adds a tremendous insight to the designer's knowledge of the response of a sampled-data system is explained, as based on the system shown in Fig. 1A. The $C(z)$ for the system with any known input is obtained by conventional z-transform methods. $C(z)$ can be expanded in partial fractions and with the aid of Table I, $C(s)$ can be found with a term-by-term identification based on this table. From $C(s)$, the pole-zero configuration of $G(s)/1+G(s)$ can be found. This pole-zero configuration is the pole-zero configuration of a continuous system which has an output that takes on the same set of values at the sampling instants as does the output of the sampled-data system. This technique enables the designer of sampled-data systems to use all the experience he has gained and all the material now available in the literature concerning the response of continuous systems to the type of input being considered. For example, if the input to the sampled-data system is a unit-step function, the pole-zero configuration of the corresponding continuous system will give the designer a picture of the overshoot and settling time, etc. of the sampled-data system.

One of the advantages of the z-transformation method

Table I. Short List of z-Transforms

Time Function	Laplace Transform	z-Transform
$u_0(t)$	1	1
$u_{-1}(t)$	$\frac{1}{s}$	$\frac{z}{z-1}$
t	$\frac{1}{s^2}$	$\frac{Tz}{(z-1)^2}$
e^{-at}	$\frac{1}{s+a}$	$\frac{z}{z-e^{-aT}}$

Table II. Short List of Modified z-Transforms

z-Transform	Modified z-Transform
$\frac{z}{z-1}$	$\frac{z}{z-1}$
$\frac{Tz}{(z-1)^2}$	$\frac{Tz}{z-1}+\frac{Tz}{(z-1)^2}$
$\frac{z}{z-e^{-aT}}$	$\frac{e^{-aT}z}{z-e^{-aT}}$

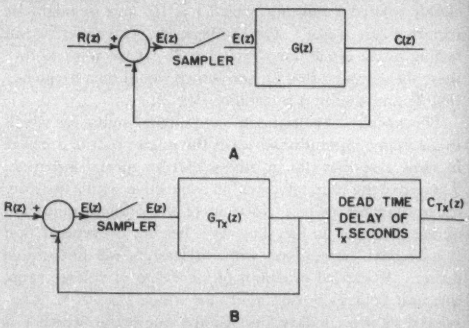

Fig. 1. Sampled-data system and hypothetical system used to find output at any time

is that the denominator of $C(z)$ can be divided into its numerator to obtain a power series in $1/z$, and thus places in evidence the successive sample amplitudes of $c(t)$. One of the disadvantages of the present z-transformation method is the uncertainty surrounding the behavior of the system between sampling instants. This limitation can be removed by the following method without losing the advantage mentioned in the foregoing.

The system to be considered is that of Fig. 1A, while Fig. 1B shows the hypothetical circuit after the artifices to be employed in this technique are added. When $E(z)$ and $G(z)$ are multiplied together in the z-domain, the corresponding occurance in the time domain is the convolution of the train of impulses of $E(z)$ with the train of impulses of $G(z)$. Consequently, the same type of operation can be performed by obtaining a new function $G_{Tz}(z)$ from values of $g(t)$ at a set of points that occur Tx seconds after the sampling instants. This technique leads to a modified z-transform, a few examples of which are shown in Table II. The usual $G(z)$ can be found by conventional z-transformation methods. This $G(z)$ is expanded in partial fraction form and $G_{Tz}(z)$ is then obtained from a term-by-term identification using Table II. From this a $C_{Tz}(z)$ can be found, and by dividing denominator into numerator the values of the output, Tx seconds after the sampling instants, can be obtained. As many points as desired can be found, so that the nature of the continuous response can be seen.

Digest of paper 54-523, "Additions to Z-Transformation Theory for Sampled-Data Systems," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Published in AIEE *Transactions*, vol. 73, pt. II, 1954 (Jan. 1955 section), pp. 403–08.

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Designing to Reduce Maintenance Costs

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Maintenance is a broad subject and not exclusively confined to electrical installations. However, so as to be of practical value to electrical engineers, this article is confined to this field.

MAINTENANCE costs play an important role in the selling price of any product and may be the difference between profit and loss to any company. It would be difficult to eliminate entirely maintenance costs on the production of any product, but they can be held to a minimum with proper precautions in the original design. Even with proper precautions in the original design, low maintenance costs will not be achieved with a loosely knit maintenance organization, loose methods, and inefficient equipment. Maintenance must be thoroughly planned, and the shop must be well equipped and have trained personnel in order to be most effective. It is essential that a complete equipment inventory be made and recorded with a case history of inspection data. The frequency of inspection would depend on how critically the equipment is related to production.

Therefore, in order for the original design to be most effective in reducing maintenance costs, it is imperative that the necessary precautions be taken by management to select a competent electrical engineer who has a thorough knowledge of the process and the difficulties that may be encountered with the electrical part of the process. Quality and production of materials in any process today are both closely related to satisfactory operation of all electric equipment required in such processes. The days of other types of power transmission and control are outmoded and have been supplanted by electric power because of its ease and economy of transmission, its precision control of speed, and timing. However, to take full advantage of these new types of drives, it is essential that reasonable care be exercised in order that specifications for the proper electric equipment may be included in the basic design for any process or project which will have a direct bearing on maintenance later.

Suppose for instance, that ways and means of obtaining engineering data are considered so that specifications may be properly prepared covering an electric installation, keeping in mind practical recommendations for reducing maintenance costs. The procedure should be as follows:

1. Establishing facts.
2. Preparing scope of work.
3. Planning and scheduling.

ESTABLISH FACTS

IT IS essential that a general meeting be held by the interested parties in order to establish the basic facts of any process or project under consideration before proceeding with the design. To be sure that all factors that may affect maintenance may be considered, it is conceivable that representatives of the following groups be in attendance at this meeting to express their interpretation and opinion of the requirements: technical, operations, process, mechanical, civil, architectural, chemical, power, and electrical engineers, depending on the magnitude of the project. It is true that on many small installations the extent of the personnel must be limited as there may be no justification of the expenditures unless the job warranted it, such as a new process and/or development.

The individual assigned the responsibility of the electric installation at this meeting should secure the basic facts such as:

1. Extent of electrical requirements (power, heating, and lighting) expressed in horsepower, kilowatts, voltage, and frequency.
2. List the categories of hazards involved:
   - A. Corrosion.
   - B. Vibration.
   - C. Electrolysis.
   - D. Contamination.
   - E. Explosive or flammable vapors.
   - F. Dust and lint.
   - G. Moisture and/or atmospheric conditions.
   - H. High ambient temperatures.
   - I. Protection of equipment due to operator's error.

Among the personnel assembled, the electrical engineer because of his intimate knowledge of electric equipment and materials is in an excellent position to suggest ways of eliminating or reducing the adverse conditions. However, to be effective in reducing maintenance costs, the electrical engineer must foresee the difficulties beforehand and design accordingly. These items will be discussed later and some corrective measures for reducing maintenance costs will be suggested.

SCOPE OF WORK

AFTER the electrical engineer has confirmed the basic data, he should prepare a Scope of Work giving the electrical requirements and the expected difficulties, all written in a concise manner for future reference so that the

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established facts will not be overlooked when specifications are prepared for the ordering of the electric equipment.

PLANNING AND SCHEDULING

DO NOT DISMISS lightly these items in considering ways of reducing maintenance costs for it might prove a boomerang. Unless arrangements are made to provide sufficient space to service the electric equipment, normal or regular inspection of the equipment will be neglected, and severe and costly breakdown of the equipment may result. In the initial design planning there must be provided the following for making the equipment easy to maintain:

1. Accessibility.
2. Drawout or plug in units.
3. Adequate terminal strips.
4. Transparent inspection plates.
5. Adequate space around equipment.
6. Adequate protection from bad weather.
7. Installed spares with closed-circuit transition.
8. Simplified wiring and controls.
9. Adequate number of spare wires in multiconductor control cables, etc.
10. Adequate number of disconnecting and isolating devices.

The scheduling of the receipt of the electric equipment to the job site and the timing of placing it in its permanent location must also be considered, as severe damage may result when in storage from atmospheric conditions and/or foreign materials accidentally coming in contact with the equipment during the construction period. An example might be cited from experience involving two voltage regulators which were severely damaged during storage. At the last moment, an attempt was made to repair them in the field and preliminary checks indicated they should operate satisfactorily; however, when placed in actual service their performance was very erratic and, consequently, they had to be returned to the factory for precision adjustment. During the interim, while operating on hand control, the voltage stability was lost causing a complete shutdown of the plant. Any unscheduled shutdown is costly regardless of the process involved and more so in a textile plant where thousands of threads may be involved.

CORRECTIVE MEASURES

IT is well to analyze some of the causes for maintenance on electric systems as listed in the preceding category of hazards and give some corrective measures that should be incorporated in the initial design for reduced maintenance costs.

1. *Corrosion*—Again, the electrical engineer should establish facts as to the type of corrosion, whether from acids and/or alkalies. Corrective measures may be:

Use of oil-immersed starters and pushbuttons.
Use of oil-immersed lighting and power panels.
Remote control rooms properly sealed and ventilated.
Extra dips and bakes on motors, transformer windings, and operating coils.
Use of TENV or TEFC motors.
Vaporproof lighting units.
Special wire and cable insulation.
Use of aluminum, fiber, plastic, or hot-dipped galvanized conduit.
Use of Neoprene latex paint for shunts and moving connectors.
Clear varnish and/or rubber paint on exposed copper parts.
Use of no oxide compounds on contacts.
Special plating of current-carrying parts.

2. *Vibration*—To eliminate faults that may be caused by vibration, it may be necessary to consider:

Special bracing of motor winding for X line starting.
Dynamic balancing of motor-driven equipment especially those in the higher speed category.
Adequate foundations for equipment.
Special lamp bulbs and/or flexible mountings for lighting fixtures.
Resilient mountings for equipment to eliminate false or improper operation of relays and coils.

3. *Electrolysis*—This may require:

Proper bonding.
Neoprene jacketing of lead-covered cable.

4. *Contamination*—Consideration should be given to:

The use of aluminum or plastic conduit, enclosures, lighting fixtures where ferrous materials will contaminate the product instead of steel, and which must be taped with varnish cambric tape and/or painted.

5. *Explosive or Flammable Vapors*—The electrical engineer should establish the range, volatility, toxicity, flash-point, and code classification which may dictate:

The use of oil-immersed starters and pushbuttons.
The use of oil-immersed lighting and power panels.
Remote control rooms properly sealed and ventilated.
Vaporproof lighting units.
Explosion resisting equipment.

6. *Dust and Lint*—The corrective measures should be:

Lint- and dust-tight enclosures.
Lintproof and/or TENV or TEFC motors.
Remote control room.
Adequate ventilation.

7. *Moisture and/or Atmospheric Condition*—The electrical engineer should establish the extent to which the following should be considered to meeting these conditions:

Vaporproof lighting.
Extra dips and bakes of motor winding.
Splashproof or TEFC motors.
Remote control room.
Special wire and cable insulation.
Weatherproof enclosures.
Space heaters in equipment to eliminate condensation.
Control of the atmospheric condition.
Prevention of mildew or fungus growth by draining and venting of conduit and equipment.

8. *High Ambient Temperature*—To meet this condition, the following may be considered:

Equipment with high-temperature insulation.
Ventilation to reduce temperature.

Derating of equipment.
Special lubrication.

9. *Protecting Equipment due to Operator's Error*—This may be accomplished by:

Signals and/or alarms.
Interlocking.
Simplified control.
Safety and limit switches.

In addition to the foregoing, other protective devices are necessary for continuity of service and when properly installed result in reduced maintenance costs. The following items must also be considered in design:

Surge and lightning protection for outside lines.
Surge protection for rotating equipment.
Over insulating of primary cable and switches.
Selecting premium grade insulation on cables to meet the conditions.
Proper grounding of equipment and system.
Primary and secondary breakers having proper interrupting and current-carrying capacity.
Cables and current transformers having proper capacity.
Protective relays with proper settings.
Eliminate overloading of motors.
Presealed bearings on motors that are inaccessible.
Dry type transformers instead of oil-insulated where possible.
Drawout breakers and motor-control centers having drawout units.
Proper torque motor application (high, normal, constant, and variable).
Equipment designed for excessive current braking.
Proper starting equipment to eliminate belt slipping and shock to mechanical parts.
Overspeeding of rotating equipment.
Ventilation of fluorescent lighting fixtures.
Fireproofing cables in manholes and vaults.

ADVANTAGES AND DISADVANTAGES

PROPER DESIGN of a program has the following advantages:

1. Lower maintenance cost.
2. Better personal relations and morale.
3. Promotes safety.
4. Reduces depreciation charges.
5. Increased profits through continuous production or avoiding loss of production.
6. Reduces manpower requirements in maintenance.
7. Reduces loss time to production workers.
8. Reduces inventory of spare parts, thereby reducing capital investment on which a profit must be realized.
9. Reduces overtime and higher labor costs.
10. Possibility of reduced insurance through proper electrical installation.
11. Longer life expectancy of electrical equipment.
12. Higher quality production thereby enabling management to better meet competitition.
13. Keeps the plant running at top efficiency in spite of shortages of new machines, equipment, and supplies.

The disadvantage of designing for reduced maintenance cost can be briefly stated as higher initial cost. However, it is economically sound and justifiable when compared with the advantages gained.

CONCLUSION

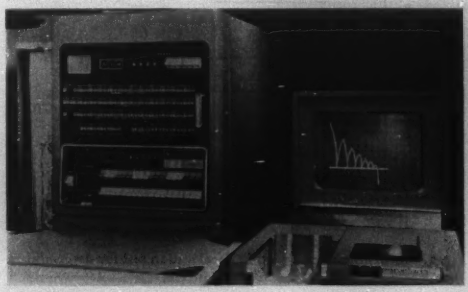
A WORD of caution may be said to those primarily interested in maintenance work. Should difficulties be experienced with any electrical installation, these difficulties should be reported to the supervisor or management. This is the best way that the design engineer may correct difficulties on future installations, for once management is conscious of the problem they become intensely interested in correcting the difficulties. It is wisely said an ounce of caution is worth a pound of correction.

Reduced maintenance costs can be accomplished by sound engineering at an economic value. This value is somewhat like an insurance policy. Best results are obtained from sound policies and likewise best results of reduced maintenance costs are from sound engineering in the original or basic design. Let us remember in basic design if you plow deep for information, you will reap a better harvest; on the other hand, shallow plowing can easily cause increased maintenance of operating equipment.

Output Recorder Provides Calculator With "Windows"

"Giant brains" soon will be provided with "windows" into which engineers and scientists can peer to see exactly what goes on inside the electronic craniums. Actually, the "windows" will be cathode ray tubes on which the big calculators' innermost "thoughts" will be pictured in the form of graphs, geometrical figures, or engineering symbols.

The new device, announced by International Business Machines Corporation, is known as the Type *740* Cathode Ray Tube Output Recorder, and was designed for use with IBM's Type *701* and *704* Electronic Data Processing Machines, eighteen of which are now in use by leading American industries and in government agencies.



Evaluating the Effect of Nonlinearity in a 2-Phase Motor

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A 2-PHASE induction motor is inherently a nonlinear device, but normal practice in the design of servomechanisms has been to represent it with a linear transfer function. This is obtained by assuming that the speed versus torque curves of the motor, for fixed reference field voltage and various values of control field voltage, are parallel straight lines. The result of this assumption is of the form

$$KG = \frac{K}{S(S\tau + 1)} \tag{1}$$

Only the straight-line portions of these curves, sections below 50-per-cent full speed, need be considered. A more accurate representation of the motor transfer function can be obtained by taking into consideration the fact that the slopes of the curves are a function of the control field voltage. If this is done a transfer function is obtained which has the same algebraic form as equation 1, but the K and τ are variables given by

$$K = \frac{A}{\left|\frac{\partial T}{\partial \omega}\right| + F} \text{ radians/second/volt} \tag{2}$$

$$\tau = \frac{J(2.590 \times 10^{-3})}{\left|\frac{\partial T}{\partial \omega}\right| + F} \text{ seconds} \tag{3}$$

where

A = stalled torque at rated voltage/rated voltage

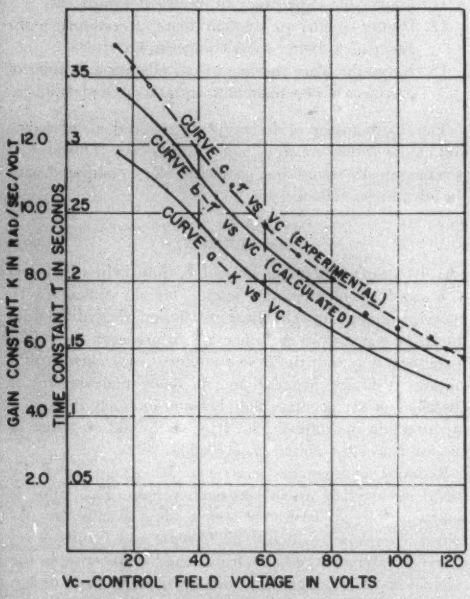

Fig. 1. Curves of time constant and motor gain versus control winding voltage

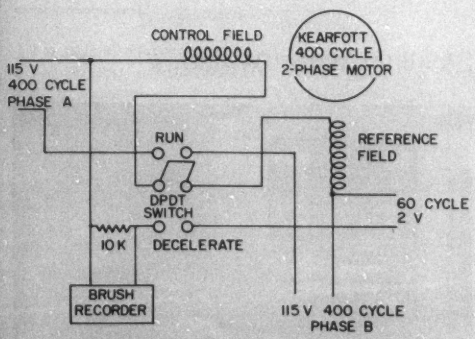

Fig. 2. Switching circuit used in deceleration test for determining moment of inertia

Both K and τ are functions of the magnitude of the control field voltage V_c, and when evaluated for a specific motor and load will appear as in Fig. 1. K is readily evaluated from steady-state tests and is the ratio of the steady-state speed to the control field voltage. τ may be measured by step function testing, or by calculation, if J is evaluated by a special retardation test which is discussed in the appendix.

The stability of a system may be checked by applying Nyquist's criterion where the motor transfer function is represented by equation 1. The numerical values used for K and τ, however, are selected from the curves of the functions. If the analysis shows that the system is stable, the transient oscillations will be damped. However, such oscillations may not disappear because the normal reduction in V_c increases both K and τ, thus reducing stability and perhaps resulting in low amplitude hunting. The existence and magnitude of such a perturbation may be investigated by inserting values of K and τ corresponding to successively smaller values of V_c.

The inertia of motor and load may be measured by means of a series of deceleration tests. The motor may be used as a tachometer by means of a simple switching circuit shown in Fig. 2. External inertia versus time constant of the speed decay is made, and extrapolation gives the motor-load inertia.

Digest of paper 54-522, "Evaluating the Effect of Nonlinearity in a 2-Phase Motor," recommended by the Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-15, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Permanent Magnet Excited Synchronous Motors

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FRACTIONAL-HORSEPOWER synchronous motors are generally available for quantity production in only the reluctance or hysteresis types. The reasons for this are: the simplicity of their rotor constructions, because of the omission of d-c excitation; and the possibility of assembling the rotors of either type in standard induction motor frames. Unfortunately, these advantages are offset by inferior performance characteristics, such as low efficiency, low-power factor, and low output, when compared to that of the same size induction motor. The locked rotor torque is also low and in the reluctance type, extremely variable.

In view of these conditions, and in response to an increasing demand, a developmental program was set up to produce a better type of synchronous motor. This was carried on intensively for several years until a motor was evolved having very satisfactory characteristics. The secret of success was the restoration of the advantages of d-c excitation without introducing its complexities. This was accomplished by inserting a powerful permanent magnet inside the rotor of an induction motor. The inside rotor diameter was so chosen as to leave a soft steel ring under the cage bars of adequate section to carry the a-c starting and accelerating fluxes, and to act as a keeper for the magnet, which was designed to be magnetized in place after assembly in the rotor. Radial interpolar slots were also punched in the rotor ring to direct the magnet flux into the stator.

The synchronous motor described above has been given the name "permasyn." It has very superior operating characteristics. It combines the good starting and accelerating performance of an induction motor with the high efficiency and power factor obtainable in a d-c excited synchronous motor. In a given frame, the rating approaches and may even exceed that of an induction motor. It is by far the best fractional horsepower motor ever built for synchronous applications, and may be competitive with induction motors on some applications where synchronous speed is desirable but not necessary. Successful permasyns have been built using all of the common single-phase stator constructions, but for simplicity this exposition is confined to polyphase motors.

In most of the permasyn motors now in use all poles of the permanent magnet are in one casting. However, more recent and better construction makes use of individual block castings, one per pole. In the case of a 4-pole rotor, a square section steel shaft is used, and the blocks are shrink-fitted into position between the shaft and the inside bore of the rotor; the fit being sufficiently tight to transmit, without slippage, any torque that the rotor can develop. The block construction has a two-fold advantage: the unit size of casting is reduced, which means that permanent magnet excitation can be applied to much larger rotors before a casting-size limitation is reached; and the block assembly is much more resistant to the demagnetization caused by slipping the rotor in and out of synchronism; this characteristic is translatable into greater output.

Table I. Comparative Performance of 60-Cycle, 4-Pole, 3-Phase, GE 45-Frame Motors

Motor	Hp Rating	Amperes Per Phase: No Load	Amperes Per Phase: Full Load	Per Cent Full-Load Efficiency	Per Cent Full-Load Power Factor	Maximum Synchronous Watts Output
Standard Induction 220-Volt Test	1/4	0.7	1.05	78	78	
Standard Reluctance 220-Volt Test	1/4	2.15	2.4	61	34	280
*220-Volt Permasyn 220-Volt Test	1/2	0.7	0.95	82	82	610
**220-Volt Permasyn 260-Volt Test	1/2	1.1	1.5	78	70	780

*Block rotor type: rotor stabilized 242 volts; demagnetized 20 per cent.
**Block rotor type: rotor stabilized 286 volts; demagnetized 30 per cent: full load loses about 100 watts, well within capacity of frame.

After saturation flux has been applied and the rotor removed from the magnetizer, it will be found that very little demagnetization has occurred. When this rotor is assembled in its stator, the external reluctance will decrease, and most of the flux will cross the air gap. Under this condition, the magnet density will rise along a minor loop to a value of about 9,500 gauss, which is only some 10 per cent below the residual induction point of alnico VI. This is the greatest amount of magnet flux that will ever enter the stator. It may be measured by driving the rotor with another motor at a definite speed and noting the generated voltage.

If the stator winding is now connected to a normal power source, the rotor will start and accelerate like that of any squirrel-cage induction motor. As the speed approaches synchronism, the attraction of the unlike poles of the magnet and revolving field will pull the rotor into step. During this first accelerating cycle, when rotor and revolving field poles are in a "slip" relationship, there will be some demagnetization. This is a normal stabilization phenomenon, and its amount is a matter of design.

In general, it is possible to modify the design of a permasyn over wide limits to fit different applications. However, in very small frames, the rotor space available for the magnet becomes restricted and, at about 1/12 hp, the permasyn loses its advantage. The largest one built so far is rated 3 hp, 1,800 rpm. No difficulty was experienced in its design or manufacture; and it is reasonably certain that a 20-hp permasyn motor can be built, if cost is not a primary consideration. Table I gives a comparison of several motor designs.

Digest of paper 54-412, "Permanent Magnet Excited Synchronous Motors," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the Fall General Meeting, Chicago, Ill., October 11-15, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Nuclear Power Reactors

STUART McLAIN

As the growth of nuclear power is very rapid, it is expected that a large percentage of large new base load plants built by 1975 will be nuclear fueled. Two reactor types, reactor technical problems, and power costs are discussed in the second part of this 2-section article.

THE fourth reactor is a larger or intermediate-sized version of the homogeneous reactor under development at Oak Ridge National Laboratory. This pilot reactor is definitely longer range than the three mentioned previously; in fact a second experimental unit is now being built to obtain design data for the pilot reactor. The pilot reactor will operate at 65 megawatts of heat and produce 16,000 kw of electric energy. The present concept makes use of $UO_2.SO_4$ dissolved in heavy water. Fig. 1 illustrates the homogeneous test reactor being built to obtain additional data for design of the larger 65-megawatt reactor.

There are a number of advantages claimed for the homogeneous reactors compared with the heterogeneous reactors. Some of these are:

1. Simplified fuel preparation. The fuel may be used as a sulphate phosphate, oxide, metal, or salt; and the solutions or slurries are easily and inexpensively prepared. Compare this with reduction of an oxide by going through the fluoride and bomb reduction, casting, rolling, machining, and cladding necessary for heterogeneous reactors.

2. Chemical recovery costs are less. The preparation of the solutions for solvent extraction processes are less complicated as solution is not necessary. However, the recovery of heavy water from a heavy water system is difficult.

3. Xenon may be readily removed. Xenon 135 is formed from the fission products and is a serious poison since it has a neutron cross section of 3,500,000 or several million times those of the usual reactor structural and coolant materials. Xenon 135 also builds up after shutdown, frequently causing operational delays up to 48 hours. Excess reactivity may be built into heterogeneous reactors to override xenon, but this adds to the cost. Part of the iodine from which the xenon is formed and the xenon, may be removed continuously from homogeneous reactor solutions by depressurizing a small by-pass stream.

4. Simplified reactor systems may be used. The reactor tank is a simple sphere with inlet and outlet connections.

5. Materials of construction may be selected on the basis of use rather than neutron properties. It is obvious that for thermal reactors any membranes required to separate the reactor core solution from a blanket containing material being irradiated would have to be made of low neutron absorbing metals.

6. Flexibility of operation. Most homogeneous reactors have very large negative temperature coefficients due to liquid expansion with temperature. At the proper temperature, the power will level off and the entire plant will operate on the power demand. Increased power output lowers the temperature, permitting more fuel in the reactor, thus resulting in higher power.

7. High power densities may be obtained. The power output is limited only by the ability to pump the fuel solution through the reactor tank.

8. Radiation damage is negligible.

Some of the disadvantages of the homogeneous reactor are:

1. Only part of the fuel is in the core where it can contribute to power production.

2. Delayed neutrons will cause the external system to become radioactive making maintenance very difficult.

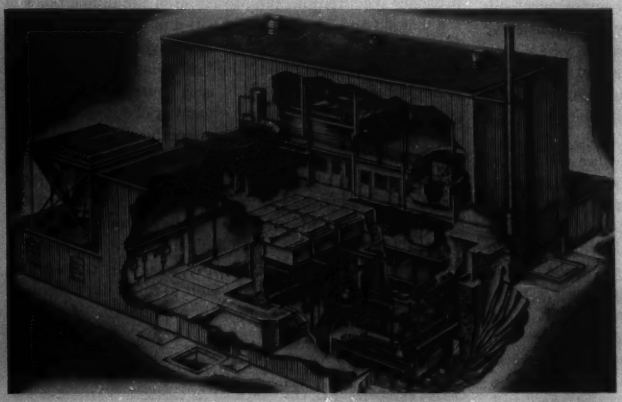

Fig. 1. Homogeneous reactor test experiment

Text of a special article recommended for publication by the AIEE Committee on Nucleonics and presented at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954.

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3. Corrosion may be greater than in the heterogeneous reactors.

4. Gas formation may be greater in homogeneous water solution reactors than in heterogeneous reactors.

5. Leaks are very serious since they include fission products and plutonium or U-233.

6. Slightly higher enrichment is required in uranium reactors due to increase in resonance absorption.

7. There is no fast fission effect in thermal reactors.

The fifth reactor project is an intermediate-sized fast breeder under development at Argonne National Laboratory. The experimental breeder reactor, *EBR-I*, at Arco has already demonstrated breeding at a 1,400-kw of heat power level. Fully enriched U-235 was used in *EBR-I* in a reactor core about the size of a football. The reactor was cooled with NaK and was the first reactor to produce electric power, see Fig. 2.

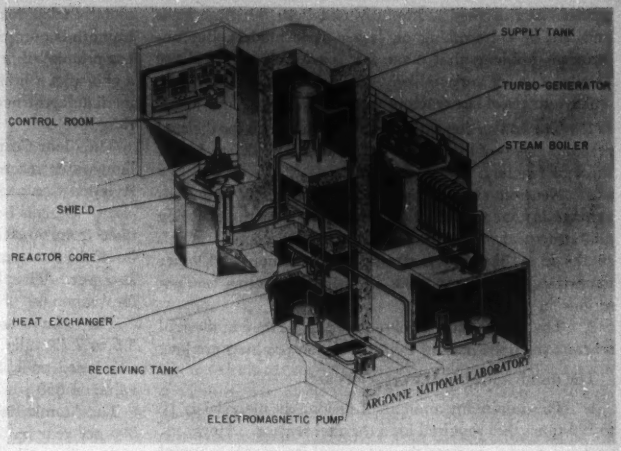

Fig. 2. Experimental breeder reactor, EBR-I

In this reactor NaK (an alloy of sodium and potassium which is molten at room temperature) coolant is forced through the reactor and heat exchanger by gravity flow, and then returned to the supply tank by the electromagnetic pump. The secondary coolant is also NaK and this is circulated through the steam boiler to form steam at 400 psi.

The intermediate-scale reactor is designed as the next step in the development of the full-scale power breeder. The fuel will be diluted with depleted uranium to form a larger core and permit higher power production. The heat production will be 62.5 megawatts with a net electric power output of 15,000 kw. A depleted uranium blanket will surround the core for production of plutonium or breeding. The reactor will be cooled with sodium which will leave the reactor at 1,000 F to produce, through a NaK heat interchange, steam at 1,800 psig. The sodium will be circulated by an electromagnetic pump driven in turn by a homopolar generator. The homopolar generator will produce 200,000 amperes up to 3 volts.

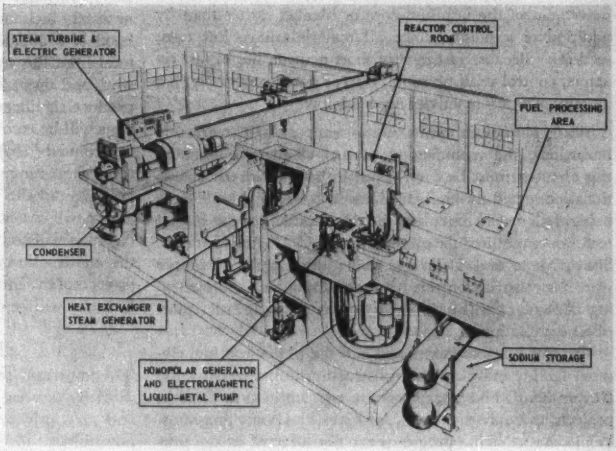

Fig. 3. Intermediate breeder reactor, EBR-II

The electromagnetic pump will handle 10,000 gpm (gallons per minute) at 60-psi head. The cross section of the pump throat will be 6 inches in the direction of the magnetic field of 6,000 gauss and 18 inches in the direction of the current.

The Intermediate Breeder or *EBR-II* is definitely a longer range project than the first three projects. It is planned to build the reactor at Arco. Exponential experiments are being run and a zero power reactor or critical assembly is under construction at Arco, see Fig. 3.

The full-scale breeder might be quite similar to *EBR-II*. The core would be larger and more heat would be produced. To circulate the additional sodium, more pumps and heat exchangers would be added rather than the size increased. For this reason, the *EBR-II* is a real pilot plant. It should be remembered that insurmountable difficulties may yet be found in the development of the Fast Breeder Reactor.

EBR-I has run very successfully and both the Americans and British are working on larger scale models, but unforeseen problems that make fast reactors impractical are possible but are very unlikely.

Advantages of fast reactors are:

1. The conversion ratio is much higher than for thermal reactors, being of the order of 1.5 for fast and 0.7 to 1.0 for thermal reactors.

2. Neutron cross sections are lower. This is an advantage in that stainless steel may be used as the cladding and structural material along with sodium coolant. This results in a high thermal efficiency. Xenon and other materials which are poisons in thermal reactors are not serious in fast reactors.

3. The amount of control required is less than in thermal reactors since the poisons from the fission products are low.

The disadvantages of fast reactors are:

1. The minimum amount of fissionable material is 10 to 100 times that required for a thermal reactor. However, for large power reactors, the amount of fissionable material in a thermal reactor may be several times the minimum in order to have adequate heat-transfer surface.

2. Control of a fast reactor must be carried out by movement of the uranium core or blanket rather than by addition of a poison, since all materials have low cross sections. Because of the very short neutron life in fast reactors, control must be rapid, but, as noted previously, the amount of excess reactivity needed is low.

Since plutonium emits alpha rays and is extremely hazardous, the manufacture of fuel elements containing this element must be carried out in hoods with all operations conducted through glove boxes. A special building is being designed to carry out the development of the special techniques required for plutonium and U-233 fuel elements. Shaw, Metz, and Dolio are doing the architect-engineer work for construction this winter at Argonne. An operating pilot plant will be built as a part of the breeder pilot plant installation at Arco.

The five reactors mentioned and the plutonium fuel element facility make up the construction authorized by the Government's Five Year Program. In addition to these six projects, there are the Naval, Air Force, and Army programs. While these defense programs are not directed at the production of civilian power, they have contributed and will continue to contribute technical "know how" and ideas. As noted, the Shippingport Reactor is a follow-up of the work on the Submarine Thermal Reactor at Argonne and Westinghouse. Likewise, important work on liquid metals and components has been done at Knolls Atomic Power Laboratory by the General Electric Company as a part of their work on the Submarine Intermediate Reactor. The work on the so-called "Packaged Power Plant" for the Army will be directly applicable to small civilian power plants—as a matter of fact, many features of such plants might be identical.

While not included in the Five Year Construction Program, there is a large Government program of reactor development in general and on specific reactors in some cases. Brookhaven National Laboratory is developing the liquid-metals-fueled reactor in which a solution of uranium in bismuth is pumped through the reactor. This reactor also has promise of producing economic power, but at the time a choice of a limited number of reactors was made for immediate construction, this reactor appeared to be a longer range project.

The Fluor Corporation has been designing a pressurized-light-water reactor in co-operation with North American Aviation Company. The installation cost is $174 per kilowatt. Designs have been made of different plants to produce from 60,000 up to 300,000 kw. The reactor could be of the dual-purpose type and produce plutonium as well as power. The plutonium could be sold to the Government for weapon use or recirculated to the reactor.

The estimates of power costs as made by Fluor vary from 5.5 to 7.75 mills per kwhr. The lower value of 5.5 mills was based on U-235 costs of $20 per gm, and the higher value on $50 per gm U-235.

The Atomic Energy Commission spends about $125,000,000 per year on development, construction, and operation of experimental reactors for all purposes including defense. This figure includes the cost of the auxiliary fuel fabrication and chemical processing plants. The total cost of construction of the five reactors discussed above, along with the necessary fuel and chemical plants, will be in the neighborhood of $100,000,000 with perhaps another $100,000,000 total from the yearly budgets used for direct development work and operation costs. The Shippingport Reactor will produce significant amounts of power and a portion of its costs will be recovered. The Duquesne Electric Company contributed $5,000,000 towards its construction. The three short-range projects, i.e., the Pressurized Water, the Boiling, and the Sodium-Cooled Graphite-Moderated Reactors, will be completed in 1956 or 1957. North American Aviation will contribute about $2\frac{1}{2}$-million dollars towards the construction of the latter one. The two longer-range projects of the Intermediate Homogeneous and Fast Breeder Reactors will be completed in 1958 and 1959.

INDUSTRIAL PROGRAM

In addition to the Government's program outlined briefly, several Government agencies or organizations and 16 private industrial groups are studying the possibilities of building economical power reactors.[1] Other groups are being organized. The Detroit Edison and associated companies have a sizable design and development program. The Nuclear Power Group, the Monsanto Chemical Company, and the General Electric Company have sizable design and study groups. The latter has recently announced interest in the boiling reactor and the high-pressure water-cooled graphite-moderated reactor. Westinghouse Electric Company is directly involved in the Shippingport Reactor as is the Duquesne Electric Company. Except for the Shippingport Reactor, none of these groups has made any announcement concerning specific plans to build reactors.

The Commission has announced recently that it will consider the best design each year for partial Government support on the basis of plutonium purchase. This is a return to the dual-purpose concept.

In addition to private groups, the Tennessee Valley Authority and other Government agencies are watching nuclear-reactor developments to see if they should build nuclear-energy plants.

DISCUSSION

The objective of the Government's program is to provide the technical information necessary for design of full-scale power reactors. The medium-sized plants appear to be large enough that most technical problems will be met and extrapolation to full-scale plants can be made. Actually, these pilot or intermediate-sized plants will use many items of equipment such as fuel elements, pumps, and heat exchangers which will be, or at least will approach, full scale. In the full-scale plants several pump and heat exchanger loops will be used in parallel.

After the pilot plants are placed in operation, they will be used for experiments designed to improve the operation or to increase the power levels and to reduce the costs of reactors.

The main technical problems that must be solved are primarily those involved with heat removal and safety. Heat removal in heterogeneous reactors is dependent on the development of satisfactory fuel elements and the utilization of these fuel elements at high heat-transfer rates as indicated earlier. Progress has been made on the fuel element problem and reasonably satisfactory fuel elements have been produced. The costs have been high and a very great amount of development work still remains to be accomplished.

Most of the fuel element development has been directed at complicated designs. Simpler, more readily manufactured fuel elements must be developed. To be economic for power production only, a burnout of at least one and preferably two atoms per hundred is required. This results in the addition of one or two atoms per hundred and the displacement of literally all the atoms present in the fuel element many times during its life. Not only must the fuel withstand these stresses and strains, but the heat-transfer rate through the metal must remain high. Luckily, the damage to the fuel-element cladding is only that caused by the neutrons and gamma rays.

The second problem is that of heat-transfer rates. It is desirable that rates of 1,000,000 to 2,000,000 Btu/square foot hour be obtained, and even higher rates are desired. To get such rates requires high film temperature drops coupled with high liquid-flow rates with danger of erosion-corrosion. Rates approaching 1,000,000 with pressurized water may require film boiling. With liquid metals, heat transfer rates of 2,000,000 Btu/square foot hour may prove feasible. Flow rates of 35 to 40 feet per second appear as high as practical.

The third problem is that of safety. If it is assumed that several per cent, say 2 per cent, of excess reactivity can be added instantaneously to an operating reactor, the power will rise exponentially at a very rapid rate. Melting or gasification of the fuel elements in the reactor might occur with release of the gaseous or all the fission products. To make certain that a series of errors cannot result in such an addition of excess reactivity, the reactor control systems are designed to permit only small rapid changes in reactivity with the large changes being made slowly. Nevertheless, it is desirable that each reactor have some natural characteristic built into it that will shut the reactor down without danger of release of the fission products when an excessive amount of reactivity is present. If an inherent safety mechanism is built into the reactor, no serious harm can occur if the operator makes an error.

The control instrumentation systems are designed to override and reverse operator errors. For example, in the Materials Testing Reactor, the instruments will reverse the direction of the control rods and shut down the reactor if the operator attempts to add reactivity at a rate which is too rapid.

As noted previously, boiling in pressurized water and boiling reactors is an inherent safety mechanism since the boiling ejects the moderator. The sodium-cooled graphite-moderated reactor is potentially very safe because of expansion with temperature rises. The Homogeneous Reactor ejects some of the fuel from the core because of expansion of the liquid-fuel solution. The Fast Reactor must be studied further, although the small Experimental Breeder has proven to be very safe. As an added final precaution, sealed buildings have been designed to prohibit the spread of fission products or plutonium in case of a catastrophe. Examples are the Research Reactor Building at Argonne and the steel sphere at West Milton, N. Y., built to house the Submarine Intermediate Reactor.

In respect to economics, the Government's program of five reactors will indicate trends, but realistic costs will not be obtained, even on the Shippingport Reactor. In the first place, this reactor is too small to be really economically competitive with larger fossil-fuel-fired plants, and in the second place, the reactor is being designed necessarily on a very conservative basis. The primary requirement is that it operate successfully. Once the reactor is in operation, the heat transfer rates and power levels can be pushed upwards to determine the practical limits. It is hoped and expected that exhaustive experiments will be run on this reactor, even though it is in use for commercial power production.

All the other reactors are being constructed for experimental development work with power generation, if any, as a secondary feature. In all cases fuel element life, operation and maintenance costs, and reactor life data will be obtained. These are the precise costs that must be assumed today.

Industry is rapidly becoming acquainted with the benefits that might be derived from nuclear reactors. Not only can reactors be used for the dual purposes of production of power and weapon-grade plutonium, but also as a source of industrial chemical manufacture. The substitution of the nuclear radiations, neutrons and gamma rays, for part of the heat in pyrolytic chemical chain reactions appears possible in the manufacture of many chemicals. This permits lower temperatures with decreased side reactions. Only the briefest exploratory work along these lines has been done by the Commission, primarily by Bernard Manowitz and others at Brookhaven, and the British.[2] It is rightly an industry problem and the Commission should

only point the way. Industry should look carefully at the use of nuclear reactors for combined power, plutonium, and chemical production. The 7-year contract for plutonium production permitted under the Atomic Energy Act of 1954, combined with the production of power, chemicals, food sterilization, etc., should be very attractive.

To be economical as power plants in the United States nuclear plants must be large, of the order of 500 to 1,000 megawatts of heat. Such reactors with the power-producing equipment are expensive. Estimates run from $175 to $400 per electric kw of installed capacity, or a cost of $30,000,000 to $70,000,000 per plant depending upon the size, the inventory, and whether or not heavy water is used. Heavy water increases the capital costs, but results in substantially increased plutonium production and increased safety.

To obtain cost data, including operating and maintenance costs, will require the construction of several full-scale plants. This is industry's job. Under the "Reactor of the Year" plan, the Commission will provide some of the funds through loans or plutonium purchase agreements. While this may be necessary, industry should provide most of the funds. Five full-scale plants will require about $250,000,000 for design and construction. Other funds, presumably the Commission's, will be required for the auxiliary fuel fabrication and irradiated fuel recovery plants. It makes little difference when these plants are built, the costs will be about the same. Five plants of different types will provide really valid economic valuations and perhaps permit elimination of some of the types. Five such plants would produce about 1,000,000 kw of electric energy. Development costs for these plants should be small since the development program under way should provide the necessary information.

The cost of nuclear power is expected to be somewhere near 6 mills/kwhr after the plants are fully developed. This cost breaks down into about 2 mills for the capital costs of the power plant, 1.5 mills for the capital charges on the reactor, 1.5 mills for the fuel, and 1 mill for operation. The fuel costs are based on the assumption that 2 atoms per 100 may be burned and that high heat rates of the order of 1,000,000 Btu/square foot hour may be obtained. Present fuel fabrication and recovery costs were included along with inventory charges on "utility" accounting. The potential developed costs of the homogeneous and fluid fuel reactors is lower than 6 mills; perhaps 5 mills might be considered. Costs using present reactor designs and techniques point to an average of something like 7 or 8 mills for the first plants to be built, since these plants will necessarily be designed on a conservative basis and the power levels increased slowly after the plants are in operation.

Due to the high capital and low fuel charges, nuclear reactors will probably be used to supply base loads.

The growth potential of the nuclear power industry is enormous. By 1975, it is expected that a large percentage of large new base load plants in the industrialized countries will be nuclear fueled. Perhaps several hundred million dollars per year will be spent on the nuclear plants alone. The development of nuclear reactors for fuel-poor areas is harder to evaluate because the markets for power are low in some areas and construction costs are high. The nuclear reactor becomes most economic in units of 200,000 electric kw or so. Since at least two reactors are needed for continuous operation, the power markets must be large. Reactors might readily be used economically today to supplement the fossil-fuel-fired plants in Europe and in South Australia. The markets and electric grids are there and the fossil fuels are expensive. Small nuclear plants might be economical in areas where power costs over something like 15 mills per kwhr with intermediate-sized plants being useful in the 10 to 12 mill per kwhr range. The chief advantage to a nuclear reactor is low fuel shipping charges, but return of irradiated fuel for recovery may prove very expensive and small chemical plants may prove to be expensive.

The United States' market for nuclear power plants by 1975 is expected to be of the order of several hundred million dollars per year. This includes the turbines and complete plants. The amounts of materials required may be something like those shown in Table I.

Table I. Nuclear Materials Required by 1975

Material	Annual Tons	Total Tons
D_2O	1,000–2,000	25,000–50,000
Th	2,000–4,000	10,000–25,000
U	4,000–8,000	30,000–50,000

It is expected that the power cost reduction in large sections of this country will be 1 to 2 mills in fully developed plants below that of fossil fuel plants. This should result in an even more rapid expansion of the power industry. The use of heat pumps for home heating and increased use of electric furnaces for steel production are examples of expected changes.

The development of reactors to drive ships may prove to be economical. Advantages are, of course, low fuel weights and low frequency of refueling. However, these costs must be balanced against high construction and inventory costs. These costs may overbalance the saving in fuel.

CONCLUSION

In the 12 years since controlled nuclear fission was demonstrated in Chicago, enormous strides toward economical nuclear power have been made. In the past 2 years, since the Commission's attention has been focussed on nuclear power, progress has been especially rapid. The problems have been delineated; progress has been made toward solution of most of them; and the remaining problems are now well on their way toward solution.

To obtain the maximum benefits will require continued co-operation of industry and Government. The goal is lowered costs and increased profits. At the same time, it will help the entire world to raise its standard of living.

REFERENCES

1. Major Activities in the Atomic Energy Programs. U. S. Government Printing Office, Washington, D. C., January–July 1954.

2. How Radiation Affects Long-Chain Polymers, A. Charlesby. *Nucleonics*, New York, N. Y., vol. 7, June 1954, p. 18.

Semiconductor Devices in Regulated Rectifiers

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TREMENDOUS advances have been made in semiconductor technology during the past 5 years. One of the many fields to benefit from this progress has been power rectification. The extended area, germanium junction diode is now a reality. The possibility of using silicon instead of germanium to provide greater freedom from ambient temperature limitations looks promising. These new rectifying elements have improved the size, weight, efficiency, and reliability of rectifier equipments. To keep pace with the rectifying elements, there is need for corresponding improvements in regulating circuitry. It is the author's belief that this challenge will be met by the wider application of semiconductor devices in regulating circuits. This digest shows some uses of these devices in the feedback loop of a regulated metallic rectifier. For a more general treatment of this subject, see reference 1.

The type of rectifier chosen for an example is one suitable for charging and floating telephone central office batteries. To obtain maximum life from the batteries, the rectifier is voltage regulated for load currents within the rating of the unit. To protect the rectifier when connected to discharged batteries, the rectifier must change from constant voltage to constant-current regulation at full load. The block diagram of an appropriate circuit is shown in Fig. 1. In the circuit, the a-c input passes through a transformer to obtain the desired input voltage to the magnetic amplifier and rectifier. The magnetic amplifier, the power stage of the regulating circuit, controls the rectified voltage or current. The rectified direct current is filtered, passed through a current sensing element, and connected to the battery and associated load. Two voltage signals are fed into the gate circuit V_V and V_I. V_V is an adjustable portion of the rectifier output voltage. When the load current is within the rating, the output voltage of the gate circuit V_R is equal to V_V. In the error detector V_R is compared to the reference voltage V_S. Any change in the error voltage V_R-V_S causes a proportional change in the output current of the error detector. This signal is amplified by the current amplifier and drives the mmf-controlled magnetic amplifier, completing the negative feedback loop. The other input voltage to the gate circuit V_I is proportional to load current and is adjusted so that V_I becomes equal to V_V at full load. When V_I becomes larger than V_V, the gate circuit makes V_R equal to V_I and blocks V_V. This action switches the rectifier from constant voltage to constant current regulation.

Semiconductor devices can be profitably applied in six of the boxes in the block diagram: the rectifier, the current-sensing element, the gate circuit, the voltage standard, the error detector, and the current amplifier. The rectifier stack consists of six fan-cooled large-area germanium cells. The current-sensing element is a saturable reactor with a rectified output connected to a resistor. The voltage V_I developed across the resistor is proportional to load current. The gate circuit's simple logic function is easily obtained with two diodes. Silicon alloy diodes when biased in the avalanche breakdown region provide a convenient reference voltage.[2,3] Two 50-milliwatt junction transistors in an emitter-coupled, push-pull circuit provide an extremely stable error detector. The current amplifier is also a push-pull circuit utilizing two 50-milliwatt and two 2-watt transistors with degenerative feedback.

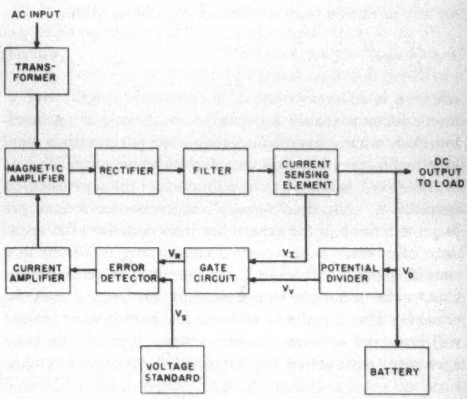

Fig. 1. Block diagram of the feedback loop

An experimental 10-kw rectifier with the foregoing type of regulating circuit has been constructed. It was found that a regulating accuracy of $\pm 1/2$ per cent (voltage o· current) is easily obtainable over the ambient temperature range of 0 to 40 C. It is concluded that the field of semiconductor technology will contribute significantly to the variety of devices available to regulated rectifier designers.

REFERENCE

1. Transistor and Junction Diodes in Telephone Power Plants, **F. H. Chase, B. H. Hamilton, D. H. Smith.** *Bell System Technical Journal*, New York, N. Y., vol. 33, July 1954, pp. 827–58.

2. Avalanche Breakdown in Silicon, **K. G. McKay.** *Physical Review*, New York, N. Y., vol. 94, May 15, 1954, p. 877.

3. The Suitability of the Silicon Alloy Junction Diode as a Reference Standard in Regulated Metallic Recsifier Circuits, **D. H. Smith.** AIEE *Transactions*, vol. 73, pt. I, 1954 (Jan. 1955 section), pp. 645–51.

Digest of paper **54-418**, "Some Applications of Semiconductor Devices in the Feedback Loop of Regulated Metallic Rectifiers," recommended by the Committee on Metallic Rectifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Published in AIEE *Transactions*, vol. 73, pt. I, 1954. (Jan. 1955 section), pp. 640–45.

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Resistance of Grounding Systems

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ANALYTICAL expressions for the resistance to infinite ground are found in the technical literature for simple shapes of ground electrodes and wires.[1] The present digest aims to establish generally applicable relations for the resistance of more complex configurations such as grids and rodbeds.

The commonly accepted formula for the resistance of a straight horizontal conductor can be modified to account for any deviation from the straight extension so that

$$R=\frac{\rho}{\pi L}\left(\log_e\frac{2L}{a'}-1+N\right) \tag{1}$$

where ρ is soil resistivity, L is conductor length, and a' is (conductor diameter × depth)$^{1/2}$. In the case of a grounding grid, where several interconnected wires with a total length of L cover a certain area A, the additive term $(N-1)$ in equation 1 will have to be a function of the dimensionless quantity $L/\sqrt{A}$, the "density" of conductor length per linear extension of the area. For infinite density the resistance of a plate is approached constituting one boundary condition for this function. As the other extreme the resistance for a simple loop encircling the area A may be chosen. The functional relation for intermediate values will have the form of a power series. Remarkably close agreement with actual test data[2] and the results of computations by others[3] is already obtained if the series is broken off after the first two terms and the coefficients are solved for the boundary conditions. The result is the general expression

$$R=\frac{\rho}{\pi L}\left(\log_e\frac{2L}{a'}+k_1\frac{L}{\sqrt{A}}-k_2\right) \tag{2}$$

for the resistance of a grid. Values of the coefficients k_1 and k_2 for different shapes of the area and various depths are plotted in Figs. 1 and 2. Values for other arrangements may be developed accordingly.

Similarly, the resistance of n closely spaced rods of L_1 length and b radius can be written

$$R=\frac{\rho}{2\pi nL_1}\left(\log_e\frac{4L_1}{b}-1+N\right) \tag{3}$$

neglecting the influence of earth fill over the top of the rods. Term N must be a function of the spacings between each of the n rods with all the other $(n-1)$ rods. The spacings in turn are related to the linear extension of the area $\sqrt{A}$. For practical cases, where $\sqrt{A}>L_1$, expression

$$N=2k_1\frac{L_1}{\sqrt{A}}(\sqrt{n}-1)^2 \tag{4}$$

satisfies both limiting conditions and furnishes results in close agreement with published data for the resistance of rodbeds.

Arrangements consisting of rodbeds and grids have a combined resistance lower than the resistance of either component, but higher than that of a plate equal to the area covered. Addition of rods will, in general, lower the grid resistance by not more than 5 per cent. This combination is, therefore, only justified to utilize the resistivity of lower strata or to provide a reliable ground source, while the grid serves as equalizer for ground fault potentials. In either case, the rodbed alone should provide the required ground resistance.

For practical purposes the expressions are unaffected by irregularities in wire or rod distribution. Thus for mats of irregular shape or interconnected grids, the resistance may be estimated by using as A in equations 2 or 4 the area enveloped by the farthest outside wire or a line passing through all rods at the extreme position.

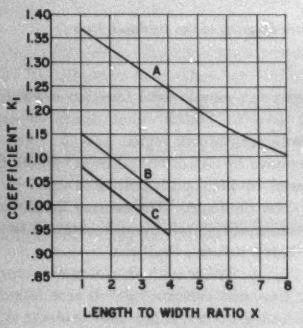

Fig. 1. Values of coefficient k_1 as a function of length to width ratio x of area

Curve A, for depth, z = 0; Curve B, for z = 1/10√area; Curve C, for Z = 1/6√area

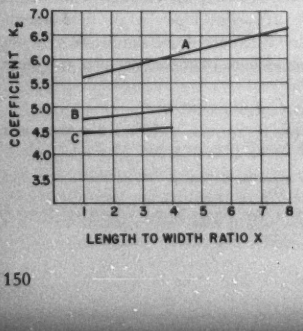

Fig. 2. Values of coefficient k_2 corresponding to coefficients k_1 in Fig. 1

REFERENCES

1. Calculation of Resistances to Ground, **H. B. Dwight.** AIEE *Transactions*, volume 55, 1936, pages 1319–28.

2. Determination of Resistance to Ground of Grounding Grids, **A. J. McCrocklin, Jr., C. W. Wendlandt.** AIEE *Transactions*, volume 71, 1952, pages 1062–64.

3. Grounding Grids for High-Voltage Stations, **E. T. B. Gross, B. V. Chitnis, L. J. Stratton.** AIEE *Transactions*, volume 72, 1953, pages 799–810.

Digest of paper 54-201, "Analytical Expressions for the Resistance of Grounding Systems," recommended by the AIEE Committee on Protective Devices and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954. Published in AIEE *Transactions*, vol. 73, pt. III, 1954, pp. 1010–16.

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Safety in College Electrical Laboratories

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It has been the unanimous opinion of the AIEE Committee on Safety that if the colleges are operating in a manner which does not bring the students' attention to the importance of safety, then those students are not being prepared properly for their work in industry. This is how one college is handling this important part of the curriculum.

ALL permanent wiring in electrical laboratories is expected to comply with the National Electrical Code. It is not the purpose of this article to deal with items that are covered in the Code but rather with general circumstances under which instruction is given within laboratory programs. The normal procedure in undergraduate laboratory teaching is to have students complete a different laboratory exercise during each class period. This involves the assembly of instruments and equipment, all to be wired properly for observation and the recording of performance data. The wiring is temporary; it is exposed. Voltages at which those temporary circuits operate may range from a few microvolts to several thousand volts as supplied by vacuum tubes, batteries, generators, transformers, or rectifiers at frequencies from zero to those encountered in the propagation of microwaves. It is safe to say that instruments and small apparatus used in laboratory experiments normally are almost never mounted permanently.

RESPONSIBILITIES OF INSTRUCTOR

UTMOST care must be exercised by the instructor that temporary wiring cannot be tripped over by anyone or that instruments cannot be pulled off the bench or table by someone accidentally bumping into the temporary leads. It is the instructor's responsibility to make a final check to see that all instruments selected are of the proper range, and that all circuits to be energized are properly fused or include a circuit breaker of proper rating and setting. He should encourage all students in the squad to follow him carefully as he checks the wiring before giving approval to proceed with the exercise.

Most students of electrical engineering are reasonably aware of the personal hazards attending electric circuits before they advance in their curriculum to their first course involving the electrical laboratories. The same may be attributed to nonelectrical students. However, the instructor must not take this for granted. He should call attention to potential hazards whenever and wherever they exist. He may sometimes forget to do this through familiarity and repetition but if he relaxes, he is neglecting what should be considered to be the most vital and serious of his obligations in the performance of his duties within electrical laboratories.

Among other obligations that the instructor should assume, and one that is owing to the students, is to impress them that they too have certain responsibilities that they must assume. A procedure that will yield good dividends to the institution is to let it be known at the beginning of each new class that in lieu of a deposit fee to cover probable damage to instruments and apparatus, the policy is to hold each and every member of a squad accountable in case of damage, the assessment against the damage being divided equally among those in the squad regardless of the individual who made the wrong move. When such a policy is enforced, damage has been found to be reduced, respect for apparatus and instruments increased, and definite responsibility is in evidence. For reasons that are well understood, the highest degree of caution seems to be exercised by the sophomores but whether the class is one of sophomores, juniors, or seniors, sooner or later someone gets careless. On learning of the assessment against the first case of damage, the tendency for others is to experience a sobering influence. Another responsibility of the instructor at the beginning of each new class might well be to acquaint the students with the approximate replacement cost of instruments and apparatus that most frequently are exposed to misuse.

RESPONSIBILITIES OF THE INSTITUTION

THERE is no safety in numbers. The age-old axiom that "one learns best by doing" forever remains a self-evident truth. Applying this axiom to the several electrical laboratories means that the size of the squad should be adjusted to the particular laboratory in a manner that each student is performing during each laboratory period and that no one is idle or just being entertained. Following this reasoning, the number of squads in the particular laboratory class should not exceed the ability of the instructor to handle the program satisfactorily and safely. There is grave danger of an unbalance occuring here through the necessary adjustment of the economic circumstances of some institutions to the increasing number of students in attendance.

It has been found that opinion varies among institutions on the need for safety education. Some feel that safety education can be over-done and that frequently there is

Revised text of a conference paper presented at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954, and recommended for publication by the AIEE Committee on Safety.

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too much stress on safety instruction for the reason that college students are in a different category than production employees in an industrial plant. Others express the opinion that a reasonably continuous introduction of caution relating to the particular laboratory exercise inherently develops safety-consciousness and students thereby form the habit of being careful.

If it were possible to lay out a perfect safety program on paper, it still would require genuine participation on the part of all instructors and all students. Pride in accomplished results has its very definite and proper place. Interest on the part of each and everyone in the laboratories must be continuous, if best results are to be achieved. Everyone performing in the laboratories must consider it to be his moral obligation to be alert at all times to circumstances under which he is working, being ever unrestrained to call attention to potentially unsafe conditions or unsafe elements in procedure wherever they are in evidence or thought to be in evidence, and never hesitate to make proposals for improvement relating to safety.

ARTIFICIAL RESPIRATION

EVERYONE who is interested in safety measures relating to artificial respiration is familiar with the instructions for resuscitation from electric shock by the prone-pressure method. Copies of instructions on this method as supplied by the AIEE Committee on Safety were framed and placed in the several laboratories of the Department of Electrical Engineering at the Iowa State College in the late 1930's. Copies also were distributed to all students entering the laboratories for the first time so that they could have them in their notebooks. The instructions were included with their first assignment. Beginning in the fall of 1954 all students are receiving a copy of instructions in the back-pressure arm-lift method. These instructions will supplant those on the prone-pressure method.

Research on artificial respiration in recent years has not only served to point out certain limitations in the prone-pressure method, but it also has served to develop modifications, or more specifically, two new methods. One is known as the back-pressure arm-lift method, popularly known as the Hogler Neilsen method, and the other as the back-pressure hip-lift method. These two new methods and their relative advantages are very ably described in a pamphlet; single copies of the pamphlet are available on request.* In December 1952, the American Red Cross, the American Gas Association, the Army, the Navy, and many other organizations adopted as standard the back-pressure arm-lift method for the reason that it is less difficult to apply than the hip-lift method; also for the reason that this method has certain advantages over the prone-pressure method.

All students should be urged to learn thoroughly at least one method of administering artificial respiration and preferably the newly developed back-pressure arm-lift method.

LABORATORY SAFETY RULES

ARISING out of experiences over the years is the compilation of safety rules that follow. They have been reproduced on sheets, 30 by 54 inches, framed, and hung prominently on walls of the Electrical Machines Laboratory at the Iowa State College.

NEVER HURRY. Haste causes many accidents.
CONNECT to the SOURCE of power LAST.
DISCONNECT the SOURCE of power FIRST.
BURNS from the ARCS may be very SEVERE.
Always ASSUME that circuit SOURCES are ALIVE. Remember that any laboratory circuit may be energized at any time.
WORK DELIBERATELY and carefully as you proceed.
VERIFY your CONNECTIONS and be sure that they have been made secure.
AVOID PLACING ANY PART OF YOUR BODY IN CIRCUIT, either to ground or across terminals.
NEVER CLOSE A CIRCUIT UNTIL INDIVIDUALS ARE CLEAR of mechanical equipment and circuit breakers.
KEEP the FACE away FROM CIRCUIT BREAKERS.
AVOID the possibility of EXPOSING your EYES TO electric ARCS, for they are powerful generators of ultraviolet light, including wavelengths that may cause serious and painful injury to the eyes, even with very short exposures.
NEVER CLOSE A SWITCH SLOWLY OR HESITATINGLY.
CLOSE AND OPEN CIRCUITS WITH SUITABLE APPARATUS.
CHECK the supply circuit VOLTAGE to see that it is what you expect—either alternating or direct current—BEFORE CLOSING CIRCUITS.
AVOID running WIRES OVER or under a BELT.
NEVER STEP OVER A BELT while it is in motion. It may break or run off at any time.
KEEP WATCH CHAINS, finger rings, wrist watches, metallic pencils, metal-bound measuring rules, etc., OUT OF CONTACT WITH LIVE PARTS when working around electric apparatus.
KEEP NECKTIES and loose clothing AWAY FROM moving BELTS or rotating parts of machinery.
USE EXTREME CARE WHEN BREAKING AN INDUCTIVE CIRCUIT.
DO NOT LIFT BRUSHES from a commutator or slip ring while machines are in operation.
DO NOT USE VOLTMETERS UNTIL the ends of the two LEADS are FASTENED FIRMLY to suitable posts ON THE INSTRUMENT.
DO NOT, UNDER ANY CIRCUMSTANCES, open the secondary of a current transformer while it is carrying current.

OTHER CONSIDERATIONS

THERE have been times within the knowledge of everyone when an accident has not resulted in an injury, or that an accident has resulted in a minor injury to which little or no attention was paid. Each of these incidences should serve as a warning to avoid repetition with probability of serious injury, and everyone, particularly those

*Pamphlet by Dr. F. A. Van Atta, Industrial Hygienist, National Safety Council. 425 N. Michigan Ave., Chicago 11, Ill.

on the teaching staff, should be acquainted with the circumstances so that immediate steps can be taken to make proper corrections.

The Department of Electrical Engineering at the Iowa State College has made a special effort to be safety-conscious over the years. Recognizing the vital importance of accident prevention in the operation of its laboratories, the staff joined as a team several years ago in making a studied approach toward the establishment of more definite instructions on safety and safety measures. Various procedures were tried and attention directed to the proper use of rotating machinery, to the proper handling of both low and high voltages, and to the importance of acquainting everyone with the location of first-aid kits, fire extinguishers, posted telephone numbers of hospitals and physicians, etc. It has been realized all along that the crowded curriculum in electrical engineering could not admit an extensive safety training program, yet the department would be derelict if it did not inform the students of the efforts to minimize the chance of accident. Students and teaching staff alike always have been urged to realize the importance of safety instruction and safety measures. They always are urged to offer suggestions for improvements.

In relation to safety, it may be emphasized that there is no substitute for good housekeeping. The staff has been particularly scrupulous about it and rightfully proud of the excellent daily appearance. Though difficult to prove, good housekeeping does have its tangible influence on accident prevention. Furthermore, good housekeeping in itself sets a good example to students though they may not be fully cognizant of it while in school.

Being mindful of the crowded curriculum, the problem then that really confronts a teaching staff is how best to maintain a high-level safety program in all of its aspects through the student's college career. Vigilance hath its rewards. Prevent the accident before it happens.

Glossary of Some Telemetering Terms

JOINT SUBCOMMITTEE ON TELEMETERING TERMINOLOGY

THIS publication is the result of the efforts of the Joint Subcommittee on Telemetering Terminology of AIEE and IRE (The Institute of Radio Engineers) to foster a common nomenclature in the various branches of telemetering. Sponsored by the AIEE through the Committee on Instruments and Measurements and its Group Subcommittee on Telemetering, and by the IRE through the Professional Group of Telemetry and Remote Control, it is not intended to be all inclusive. This sponsorship is not intended to imply agreement by the sponsoring groups with the definitions as given, nor is it intended in any way to convey approval of, or a preference for, these definitions or terminology. It is hoped that it will aid personnel in the compilation of telemetering reports and be of assistance when telemetering specifications are drafted by industrial and government establishments. It is essentially that submitted at the Workshop Session of the National Telemetering Conference in Chicago, May 1954, at the Hotel Morrison, which was sponsored by AIEE, IRE, IAS (Institute of Aeronautical Sciences), and ISA (Instrument Society of America).

The general policy governing the inclusion of terms has been:

1. No definitions to be included in the glossary unless there is a definite need for them.
2. Webster's definitions to be used if they apply.*
3. ASA (American Standards Association) definitions to be used where possible.*
4. AIEE or IRE or other authentic proposed definitions to be used with modifications only if necessary.
5. New definitions are proposed only when considered necessary and where no known suitable definition exists.

No effort has been made to include terms defined in existing formal glossaries, such as American Standard Definitions of Electrical Terms ASA-C 42. It is realized that many terms defined in other publications apply to telemetering as well, and it is expected that these documents will assist in the standardization of telemetering nomenclature. Such pamphlets include:

Automatic Control Terminology, ASME (The American Society of Mechanical Engineers)

ASME Terms from Automatic Control Section—Automatic Control

A Glossary of Terms in Nuclear Science and Technology, ASME

A few of the definitions are known to be controversial. The definitions included have been interpreted by the committee as being ones with widespread approval. It is hoped that a publication such as this will foster discussion and hasten agreement so that they may be recommended for American Standards Definitions.

* These definitions need not be repeated in the present glossary and are considered satisfactory except where they conflict with the specific terms defined herein.

A special article recommended for publication by the AIEE Committee on Instruments and Measurements.

Contributors to this work have been so extensive that it is impractical to recognize all adequately. The National Telemetering Forum submitted a list of terms which formed the initial effort. To all organizations and individuals who assisted in the preparation of these definitions the committee extends its grateful acknowledgment.

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The following is a glossary of some telemetering terms as of October 1954:

ACCELEROMETER. An accelerometer is an instrument that measures one or more components of acceleration. (a)

ACCURACY. Accuracy, if an indicated or recorded value, is a measure of conformity to an accepted standard. (b)

AMBIENT. The surrounding medium is the ambient.

AMBIENT CONDITIONS. The conditions of the surrounding medium, e.g., pressure, etc., are ambient conditions. (b)

AMPLITUDE MODULATION. Amplitude modulation, or AM, is a method of conveying intelligence by varying the amplitude of a wave. (c)

BAND. A band is a limited continuous region which is part of a more extended region. Used in connection with frequencies, pressures, etc. (b)

BANDWIDTH. Bandwidth is the extent of the band. The particular method and convention to be followed in defining the extent is to be specified. (b)

BAUD. A baud is a unit of signaling-speed derived from the duration of the shortest code element. By extension, the speed in bauds is the number of code elements per second. (c modified)

BI-DIRECTIONAL PULSES. Single polarity pulses, not all of which have the same sense of departure from normal, are bi-directional pulses. (c modified)

BINARY CODE. A binary code is a code composed of a combination of entities, each of which can assume one of two possible states, and which is identifiable in time or space. (b)

BIT. A bit is a quantity of intelligence which is carried by an identifiable entity, and which can exist in either of two states. (b)

CALIBRATION ACCURACY. The finite degree to which a device can be calibrated is its calibration accuracy. (Influenced by sensitivity, resolution, and reproducibility of the device itself and the calibrating equipment.) Usually it is expressed in per cent of full scale. (b)

CARRIER. A carrier is a wave suitable for modulating by a modulating wave. (c and d)

CARRIER-TO-NOISE RATIO. The carrier-to-noise ratio is the ratio of the magnitude of the carrier to that of the noise after selection and before any nonlinear process, such as amplitude limiting and detection. (c modified)

CHANNEL, TELEMETERING. The route required to convey the magnitude of a single telemetering measurand is the telemetering channel. (b)

CHANNEL PULSE. A pulse representing intelligence on a channel by virtue of the modulation characteristic is the channel pulse. (b)

CLAMPING CIRCUIT. A circuit which maintains either amplitude extremity or a waveform at a certain potential level is a clamping circuit. (b)

CLIPPER. A clipper is a device whose output is zero or a fixed value for instantaneous input amplitudes up to a certain value, but which has an output that is a function of input for amplitudes exceeding the critical value. (c modified)

CLIPPER LIMITER. A clipper limiter is a device whose output is a function of the instantaneous input amplitude for a range of values lying between two predetermined limits but is approximately constant at another level, for input values above the range. (c modified)

COMMUTATION SWITCH. A commutation switch is a device used to execute repetitive sequential switching. (b)

CROSS MODULATION. Cross modulation is modulation of a carrier of the desired signal by an undesired signal. (d)

CROSS TALK. Cross talk is interference in a given channel originating in another channel of the same system. (b)

DECODING. Decoding is the process of obtaining intelligence from a code signal. (b)

DETECTION. The process by which a wave corre-

(a) Modified Webster Definition
(b) New Definition
(c) Standards on Antennas, Modulation Systems, Transmitters, Definition of Terms, IRE, 1948
(d) Proposed Standards on Receivers, Definition of Terms, 51 IRE 17 PS2
(e) Proposed AIEE and ASA Definition

sponding to the modulating wave is obtained in response to a modulated wave is detection. (d modified)

DEVIATION FROM LINEARITY. In per cent of full scale, deviation from linearity is the maximum deviation of a curve from the most favorable straight line that can be drawn through the curve. The method of determining the most favorable line must be stated. (b)

DEVIATION RATIO. In a frequency-modulating system, the ratio of the maximum frequency deviation to the maximum modulating frequency of the system is its deviation ratio. (c)

DISCRETE SAMPLING. In discrete sampling, the individual samples are of such long duration that the intelligence frequency response of the channel is not deteriorated by the sampling process. (b)

DISCRIMINATOR, FREQUENCY. A frequency discriminator is a device which responds only to a given set of frequencies having a particular characteristic, such as duration, amplitude, period. (c modified)

DISCRIMINATOR, PULSE. A pulse discriminator is a device which responds only to a pulse having a particular characteristic, such as duration, amplitude, period. The latter is also called a time discriminator. (c modified)

DISCRIMINATOR, PHASE. A phase discriminator is a device in which amplitude variations are derived in response to phase variations. (c modified)

DUTY FACTOR. In a pulse carrier composed of pulses that recur at regular intervals, the product of the pulse duration and the pulse repetition frequency is the duty factor. (c)

END DEVICE. An end device is the final system element that responds quantitatively to the measurand and performs the final measurement operation. (e)

ELECTRIC TELEMETERING. Electric telemetering is telemetering performed by deriving from the measurand or from an end device a quantitatively related separate electrical quantity or quantities as a translating means. (e)

ERROR. The error of an indicated value is the difference between the indicated value and the true value of the quantity measured. (It is the quantity which algebraically subtracted from the indicated value gives the true value. A positive error denotes that the indicated value of the instrument is greater than the true value.) Usually expressed in per cent of full scale. (b)

FRAME. One cycle of a cyclically recurring number of pulses is a frame. (b)

FRAME FREQUENCY. The number of frames per unit time is the frame frequency. (d modified)

FRAME SYNCHRONIZING PULSE. A frame synchronizing pulse is a recurrent signal establishing each frame. (b)

FREQUENCY DEVIATION. Frequency deviation is the deviation in frequency from its assigned value. (d modified)

FREQUENCY MODULATION. Frequency modulation is angle modulation in which the instantaneous frequency of a sine wave carrier is caused to depart from the carrier frequency by an amount proportional to the instantaneous value of the modulating wave. (d)

FREQUENCY MODULATION DEVIATION. The peak difference between the instantaneous frequency of a modulated wave and the carrier or reference frequency is the frequency modulation deviation. (d)

FREQUENCY MULTIPLEX. A technique for the transmission over a common path of two or more signals, each characterized by a distinctive reference frequency or frequency band is frequency multiplex. (b)

FREQUENCY RESPONSE CHARACTERISTIC. The frequency response characteristic is the variation with frequency of the gain or loss of a device or a system. (d)

FREQUENCY SHIFT KEYING. Frequency shift keying is that form of frequency modulation in which the modulating wave shifts the output frequency between predetermined values and the output wave is coherent with no phase discontinuity. (c)

FREQUENCY SWING. In frequency modulation, the peak difference between the maximum and the minimum values of the instantaneous frequency is the frequency swing. (c)

FRICTIONAL ERROR. Frictional error as applied to pickups is the difference in values measured in per cent of full scale before and after tapping, with the measurand constant. It is usually expressed in per cent of full scale. (b)

HARTLEY. A Hartley is a unit of information content, equal to one decimal decision, or the designation of one of ten possible and equally likely values or states of anything used to store or convey information. NOTE: A Hartley may be conveyed by one 10-ary code element. One Hartley equals $\log_2 10$ bits; ($\log_2 10 = 3.323$). (b)

HYSTERESIS ERROR. The hysteresis error is the maximum difference in per cent of full scale in readings obtained by making a complete full scale cycle of the measurand at a specific value of the latter. It is usually expressed in per cent of full scale. (b)

INDICATOR. An indicator is an instrument which makes information available but in which there is no provision for storage of such information. (b)

INDICATION. Indication is the display to the human senses of information concerning the measurand. (b)

INTERFERENCE. In a signal transmission system interference is the extraneous power which tends to interfere with the reception of the desired signals. (d)

KEYING. Keying is the forming of signals such as those employed in telegraph transmission by an abrupt modulation of the output of a direct-current or an alternating-current source as, for example, by interrupting it or by suddenly changing its amplitude or frequency or some other characteristic. (c)

LIMITER. A limiter is a device whose output is virtually constant for all inputs above a critical value. (c)

LINEARITY. Linearity is a relationship existing between two quantities when the change in one quantity is exactly and directly proportional to the change in the other quantity. NOTE: The quantities and ranges involved must be clearly specified. (b)

MEASURAND. A measurand is a physical quantity, property, or condition which is to be measured. (e)

MODULATION. Modulation is the process or the result of the process in which the amplitude, frequency, or

phase of a wave is varied with time in accordance with a wave. (b)

MODULATION INDEX. Modulation index is a measure of the degree of modulation for any type of modulation. (b)

MULTIPLE MODULATION. Multiple modulation is a succession of processes of modulation in which the modulated wave from one process becomes the modulating wave for the next. (c)

NATURAL FREQUENCY. The natural frequencies of a body or system are the frequencies of free oscillation. (b)

NOISE. Any electrical disturbance tending to interfere with normal reception of a transmitted signal is noise. (d)

PHASE DEVIATION. The peak difference between the instantaneous angle of the modulated wave and the angle of the carrier is phase deviation. (c)

PHASE MODULATION. Phase modulation is angle modulation in which the angle of a sine wave carrier is caused to depart from the carrier angle by an amount proportional to the instantaneous value of the modulating wave. (c)

PHASE RESPONSE CHARACTERISTIC. The phase response characteristic is the phase displacement versus frequency properties of a network or system. (d modified)

PICKUP. A pickup is a device which converts a magnitude (which may be of a measurand) into a corresponding electric signal. (b)

PRIMARY DETECTOR. A primary detector is the first system element or group of elements that responds quantitatively to the measurand and performs the initial measurement operation. (e)

RECORDER. A recorder is an instrument for the storage of information concerning the relationship among variables. (b)

RIPPLE. Per cent ripple is the ratio of the effective root-mean-square value of the ripple voltage to the average value of the total voltage, expressed in per cent. (d)

SAMPLE, INTELLIGENCE. A part of a signal used as evidence of the quality of the whole is the sample of intelligence. (b)

SIGNAL. The signal in telemetering is the electrical intelligence or message conveyed. (b)

SIGNAL-TO-NOISE RATIO. The signal-to-noise ratio is the ratio of the magnitude of the signal to that of the noise. This ratio is often expressed in decibels. (d)

SUBCARRIER. A subcarrier is a carrier which is applied as a modulating wave to modulate another carrier. (c)

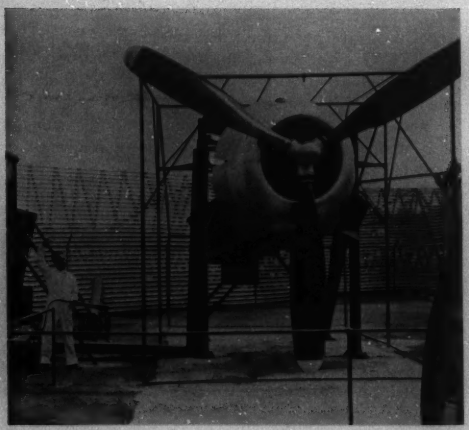
SYNCHRONISM. Synchronism expresses the phase relationship between two or more periodic quantities of the same period when the phase difference between them is zero. (e)

TELEMETERING. Telemetering is measurement with the aid of intermediate means which permit the measurement to be interpreted at a distance from the primary detector. NOTE: The distinctive feature of telemetering is the nature of the translating means, which includes provision for converting the measurand into a representative quantity of another kind that can be transmitted conveniently for measurement at a distance. The actual distance is irrelevant. (e)

TIME DIVISION MULTIPLEX. Time division multiplexing is the process of transmitting two or more signals over a common path by using different time intervals for different signals. (c modified)

(b) New definition
(c) Standards on Antennas, Modulation Systems, Transmitters, Definition of Terms, IRE, 1948
(d) Proposed Standards on Receivers, Definition of Terms, 51 IRE 17 PS2
(e) Proposed AIEE and ASA Definition

Crash Fire-Prevention Equipment Is Tested



Devices which will eliminate fires following survivable airplane crashes are tested with this elaborate setup at Walter Kidde and Company, Inc.'s Proving Ground, Belleville, N. J.

Here all airport fire safety precautions are taken when starting the Wright turbo compound engine. It is valued at $55,000, develops 3,500 hp, and is the type used to power the DC-7 and the Super Constellation. The engine is controlled from the shed (at left) which contains elaborate photographic equipment to record conditions.

Certain combinations of reaction, deformation, and inertia switches trigger the systems electrically at the moment of impact. After 0.008 of a second, they spray the nacelles with a solution which both cools and inerts them with fog; inerts the induction system with carbon dioxide; shuts off gas, oil, and hydraulic systems; actuates all normal fire extinguishing systems; and turns off all electric systems. Within 2 seconds from the crash impact, the equipment has done its work.

Silicon-Organic Resin for Dry-Type Transformers

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THE advantages of using silicone-based products in dry-type insulating systems are well known. They are characterized by stability at high operating temperatures and by resistance to the absorption and harmful effects of moisture. These advantages must be weighed against the difficulties which may arise in conjunction with silicone applications. The dielectric strength, mechanical strength, and curing characteristics for a given application are, in general, inferior to those of the best organic resins. High cost is also a limiting factor in many silicone applications.

It would obviously be very desirable to obtain a material or combination of materials which retain the good features of the best silicone and organic resins without accompanying limitations. If the functional requirements of constituents within a dry-type insulating system are considered, it may be seen that such a possibility exists. It has been well established that oxygen is a primary contributor to deterioration of organic materials in dry-type apparatus and that the thermal superiority of the silicones stems largely from their resistance to the adverse effects of oxygen. It may then be inferred that the silicones, in proper combination, can be used to extend the life of certain organic materials.

This investigation was conducted in an effort to develop a dry-type transformer insulating system, which would utilize the high dielectric and mechanical strength characteristics of selected organic impregnants, and the temperature and moisture-resistant characteristics of suitable silicones. It was desired to accomplish this in as economical a manner as possible by using a minimum of silicone resin.

Emphasis was placed on the use of silicone resin as a surface treatment of conventional 150 C base insulations. By this procedure, the silicone replaced the weakest link in the present 150 C system, the organic impregnating varnish. The organic constituent of the base material was shielded by the silicone resin coating from the deteriorating effects of oxygen and moisture.

Two criteria have been utilized in determining the aging performance of the materials under study. These are: dielectric strength at the elevated aging temperature, and power factor after exposure of the insulating component to high humidity.

It is apparent that high-temperature turn insulations, utilizing silicones as the resinous constituents, possess very stable dielectric strength and moisture-resistance characteristics as a function of time and temperature. Essentially no change was found in the dielectric breakdown of turn insulation comprising a silicone-resin-impregnated asbestos-clay sheet and glass yarn, bonded and treated with a silicone resin after 200 days at 250 C. After the same period of aging, this system is effectively as resistant as new materials to moisture effects measured by power factor. Such components are suitable for operation at temperatures well above 200 C.

High-temperature turn insulations containing an acrylic ester impregnant and treated with a phenolic varnish have previously been analyzed. The weakest link in this system is the organic final-treating varnish, and the component will not maintain its resistance to the effects of moisture throughout the minimum required life at 150 C.

When silicone resin is substituted for the organic treating varnish, the resulting composite exhibits dielectric strength and moisture resistance characteristics as a function of time and temperature which are very similar to those of the comparable system where all resins are silicones.

Mica paper, impregnated with a high-temperature polyester resin possesses dielectric strength and loss characteristics which make it very desirable for use as a layer insulation and as electrical padding for major insulation in dry-type transformers. When properly treated with silicones, the material will perform adequately at hottest spot temperatures approaching 200 C. The life at 20,000 hours on the basis of a 50-per-cent dielectric strength criterion is at least 190 C.

The merits of the final silicone treatment are apparent even with essentially inorganic structures. One insulation of this type, which is based on the discovery of a controllable phospho-asbestos reaction may be formed as cylinders for barriers between high- and low-voltage windings. Silicone treatment markedly improves the dielectric properties and moisture resistance of this structure. Prolonged exposure to aging temperatures as high as 250 C have actually been shown to be beneficial to its dielectric properties.

The dry-type insulating system containing organic impregnants and using silicones as a final treatment offers the following advantages for use in circulatory air apparatus: the thermal stability of the system is adequate for operation at hottest spot temperatures greater than 200 C; the resistance of the system to moisture is maintained throughout transformer life and is much greater than that of the usual 150 C system; the insulating components will, in general, possess mechanical and dielectric strengths greater than those of systems containing only organic impregnants; and the versatility and areas of dry-type transformer application are greatly increased by the use of this insulating structure.

Digest of paper 55-43, "Evaluation and Application of Silicone-Organic Resin Combinations for Dry-Type Transformer Insulation," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Analogue Computers Using Magnetic Amplifiers

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THIS analogue computing technique uses direct currents as variables. These currents are summed by magnetic amplifiers to perform addition and subtraction operations. Products, quotients, roots, and powers are obtained by summing other currents that are proportional to the logarithms of the variables. These logarithmic currents are obtained by networks of 5 germanium or silicon diodes and 11 precision resistors. As the input current increases, the diodes in the circuit cut in sequentially to shape the output current according to a logarithmic curve. A voltage is supplied to a voltage divider in the network controlling the switching points of these diodes.

Fig. 1 shows the basic negative feedback circuit used for computing. The logarithmic networks *LN* are applied to each of the input current leads, as shown. The "negative" network for the output current I_0 differs from the "positive" networks only in reversal of the direction of current flow, the diode connections, and the sign of the 10-volt bias voltage required. Since the input current of the magnetic amplifier is very small, the logarithm of the output is very nearly equal to the sum of the logarithms of the inputs. Thus the negative feedback accomplishes the taking of the anti-logarithm. The magnetic amplifier has sufficient current gain that its input current i causes a computational error of less than 1/3 per cent. Hence, to a close approximation

$$I_0 = \prod_{j=1}^{n} \left(I_j^{\frac{a_j}{a_0}} \right)$$

If the a's are equal, the inputs are multiplied together. If they are not equal, powers or roots of the inputs are multiplied. Also, any of the inputs may be made to be divisors by using a negative, instead of a positive network, for it. Furthermore, if addition and subtraction is desired, the networks are omitted.

At room temperature, networks made with germanium diodes give a logarithmic output with a maximum error of 0.8 per cent, for an input current range of 2 to 30 milliamperes. The effect of temperature (−55 to +70 C) is primarily to change the logarithm base, causing no additional computing error. This statement is applicable for

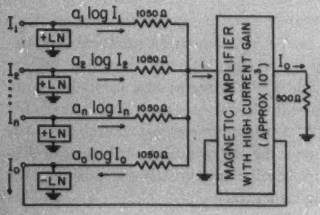

Fig. 1. Block diagram of computing scheme to sum logarithmic currents

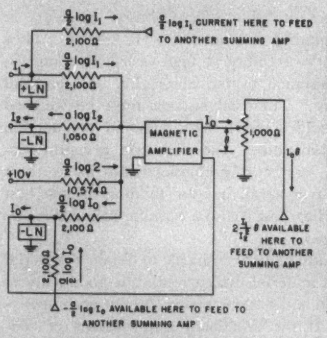

Fig. 2. Circuit illustrating some schemes used for interconnecting components to make up a computer. Also shown is the introduction of a mechanical input θ by means of a potentiometer. The symbol Δ indicates a ground potential point (the input junction of a summing amplifier)

inputs from 6 to 30 milliamperes. At low input current and high temperatures, however, the error becomes appreciable (3 per cent at 4 milliamperes). These errors are not excessive for some applications. For other applications the networks can be temperature compensated over the full current range to about the same accuracy as obtained at room temperature. This is done by using temperature-sensitive resistors in the network. The problems of temperature compensation are greatly simplified, however, with the use of silicon junction diodes.

The logarithmic networks and the summing amplifiers can be interconnected to solve systems of nonlinear equations. The method of interconnection utilizes the fact that the summing, or input, junction of the magnetic amplifier is at zero potential, see Fig. 1. Hence, currents may be independently fed into, or drawn from, this point. As an example, the output of the circuit of Fig. 1 can be fed to the summing junction of another similar amplifier. Furthermore, this current may be split into fixed fractional amounts by a simple parallel resistor network, and fed to several other circuits. Such current splitting networks are also used as shown in Fig. 2.

The computation done in Fig. 1 requires 7 ounces of components, and is performed with an accuracy of about 1 per cent. The response time is short (0.01 second, using a 400-cycle amplifier). The versatility of the technique results in a computer with a high ratio of computations per unit volume or weight, using reliable components. These desirable characteristics, together with experience to date, indicate that computers made of these two basic components should have considerable utility in military and industrial applications.

Digest of paper 54-389, "An Analogue Computing Technique Using Magnetic Amplifiers," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the Fall General Meeting, Chicago, Ill., October 11–15, 1954. Published in AIEE *Transactions*, vol. 73, pt. I, 1954 (Jan. 1955 section), pp. 635–40.

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INSTITUTE ACTIVITIES

1,750 Attend Eastern Computer Conference; West Coast Conference Scheduled March 1-3

More than 1,750 engineers and others in the computer field attended the Eastern Joint Computer Conference, December 8–10, the largest registration in the history of the conference. The conference, sponsored by AIEE, the Institute of Radio Engineers, and the Association for Computing Machinery, took place at the Bellevue-Stratford Hotel, Philadelphia, Pa.

The next one planned is the West Coast Conference, March 1–3, 1955, at the Hotel Statler in Los Angeles, Calif. The theme will be, "Functions and Techniques in Analogue and Digital Computers."

The Eastern theme was, "Design and Application of Small Digital Computers." The characteristics of commercially available small digital computers were presented so that comparisons could be made among the machines. Several systems were described in detail. Among the various improvements claimed were decimal arithmetic operation, higher speed input-output facilities, cartridge-type magnetic tape handling, and plug-board programming. A transistorized computer using 700 transistors and 10,500 diodes was described with data on the first six months of continuous operation.

Pros and cons of plug-board programming versus internally-stored programming were developed in another paper. Reports were given on the following: new techniques for increasing pulse-storage density on magnetic drums to 880 bits per inch; performance and life data of magnetic core memories and logic circuits in use for a considerable length of time; a self-checking, high-speed printer capable of printing up to 600 lines per minute (130 characters per line); and a high-speed system for telegraph transmission at the rate of 3,600 characters per minute.

Subjects of the papers concerned with application of computers were: a technique for evaluating the worth of a given numerical method in solving a set of differential equations; automatic coding methods; and systems for filing and analyzing vast amounts of data (with specific examples from the fields of library cataloging, business data handling, and aircraft flight scheduling). The use of small digital computers in scientific applications was illustrated with papers on optical design and computer logic circuit design.

Inspection trips to local computer installations were well attended, as were the exhibits of more than forty companies. Many of these companies displayed new products for the first time.

According to AIEE's Computing Devices Committee, its principal activity has been the cosponsorship with the Institute of Radio Engineers and the Association for Computing Machinery in arranging these technical conferences and exhibits. The meeting just held in Philadelphia was the sixth of a series of such conferences and exhibitions held under joint auspices. Three preceding meetings have been held on the East Coast covering, respectively, a review of electric digital computers, a review of input-output equipment, and the reliability and requirements of information processing systems. Two previous meetings have been on the West Coast, one consisting of general computer papers, and the second covering transient computers—automatic control and data processing. Proceedings of all of these meetings are available from any of the three sponsor societies. Publication of the Proceedings for the last meeting is now under way and is another of the activities undertaken by the AIEE Committee.

Active Subcommittees now include Analogue Computers, Analogue-Digital Converters, Bibliographies, Digital Computers, Digital Computer Conversion, and a West Coast Subcommittee.

All eyes are focused on the speaker at the Eastern Joint Computer Conference which was held December 8–10, 1954, in Philadelphia, Pa. More than 1,750 engineers and others working in the computer field attended the meeting—the largest registration in the history of the conference

Future AIEE Meetings

AIEE-IRE Transistor Circuits Conference
University of Pennsylvania, Philadelphia, Pa.
February 17–18, 1955
(Final date for submitting papers—closed)

AIEE-IRE-ACM Western Computer Conference
Hotel Statler, Los Angeles, Calif.
March 1–3, 1955
(Final date for submitting papers—closed)

Farm Electrification Conference
Morrison Hotel, Chicago, Ill.
March 8–10, 1955
(Final date for submitting papers—closed)

Electrical Utilization of Aluminum Conference
William Penn Hotel, Pittsburgh, Pa.
March 15–17, 1955
(Final date for submitting papers—closed)

Materials Handling Conference
Hotel Cleveland, Cleveland, Ohio
March 28–29, 1955
(Final date for submitting papers—closed)

Rubber and Plastics Conference
Akron, Ohio
April 4–5, 1955
(Final date for submitting papers—closed)

Southern District Meeting
St. Petersburg, Fla.
April 13–15, 1955
(Final date for submitting papers—closed)

Pulp and Paper Conference
St. Petersburg, Fla.
April 14, 1955
(Final date for submitting papers—closed)

Middle Eastern District Meeting
Columbus, Ohio
May 4–6, 1955
(Final date for submitting papers—February 4)

Electric Heating Conference
LaSalle Hotel, Chicago, Ill.
May 10–11, 1955
(Final date for submitting papers—February 10)

AIEE-IAS-IRE-ISA Conference on Telemetering
Morrison Hotel, Chicago, Ill.
May 18–20, 1955
(Final date for submitting papers—February 18)

AIEE-APS-AIME-CIT Conference on Magnetism and Magnetic Materials
William Penn Hotel, Pittsburgh, Pa.
June 14–16, 1955
(Final date for submitting papers—March 14)

1955 Summer General Meeting
New Ocean House, Swampscott, Mass.
June 27–July 1, 1955
(Final date for submitting papers—March 29)

Pacific General Meeting
Butte, Montana
August 15–19, 1955
(Final date for submitting papers—May 16)

AIEE Farm Electrification Conference to Be Held March 8–10 in Chicago, Ill.

The utilization of electricity on modern poultry, dairy, and livestock farms will be discussed by outstanding authorities at AIEE's Conference on Farm Electrification. This conference will be held March 8–10, 1955, at the Morrison Hotel in Chicago, Ill.

Power suppliers will discuss methods by which they are serving the present farm load, as well as future plans to serve this rapidly growing load. Problems incidental to power use, such as safety, leakage current, grounding, and underground distributions, will also be covered. There will be forums and panels and an inspection trip to up-to-date livestock, dairy, and poultry farms.

The conference will conclude with a look into the future of farm electrification, the future of an electric load which offers the greatest potential increase of any industry in the nation.

For further information about the program, advance registration, or hotel reservations, contact Mr. F. A. Larson, 840 South Canal Street, Chicago, Ill., or Mr. R. S. Gardner, AIEE Headquarters, 33 West 39th Street, New York, N. Y. The program for this conference will appear in the March issue of *Electrical Engineering*.

Conference on Utilization of Aluminum to Take Place March 15–17 in Pittsburgh, Pa.

The first national conference on the electrical utilization of aluminum will be held in Pittsburgh, Pa., March 15–17, 1955, with headquarters at the William Penn Hotel. This conference will be jointly sponsored by the AIEE Power Division Committee and the AIEE Pittsburgh Section.

The purpose of the conference is to provide an opportunity for the presentation of papers and discussions on the use of aluminum in conductors and cables, and as a mechanical and structural component in electric equipment and circuits. The broad scope of the program covers pertinent problems of aluminum manufacture, and the gamut of aluminum utilization from household electric appliances to industrial and electrical utility apparatus such as transformers, rotating machinery, bus conductors, and switchgear. The 3-day program will be published in the March issue of *Electrical Engineering*.

Since the Pittsburgh area enjoys the presence of principal manufacturers, fabricators, and industrial and commercial users of aluminum, the inspection trips which have been planned should be of particular interest. Hotel rooms are available at the William Penn Hotel. For further information, contact Mr. E. W. Brewer, conference registration chairman, General Electric Company, 535 Smithfield Street, Pittsburgh 22, Pa.

ALCOA's 30-story aluminum-sheathed skyscraper will be the scene next March 16 of an inspection trip for AIEE members during the first Conference on Electrical Utilization of Aluminum. The World's first aluminum skyscraper, the ALCOA Building uses aluminum exclusively for wiring

BANQUET AND INSPECTION TRIPS

A banquet will be held Wednesday, March 16, at 7:30 p.m. Mr. I. W. Wilson, president, Aluminum Company of America, will speak on "Man's Distinctive Mark." Also, the following inspection trips will be conducted: Westinghouse Electric Corporation, East Pittsburgh Works, Tuesday afternoon and Thursday morning; Aluminum Company of America, Research and Development Laboratories, New Kensington, Pa., Tuesday afternoon; Duquesne Light Company, Elrama Power Station, Wednesday afternoon.

REGISTRATION AND PROCEEDINGS

Registration in advance may be made by sending in a registration card. Cards may be obtained from Mr. E. W. Brewer, General Electric Company, Pittsburgh 22, Pa. Advance registration will facilitate conference preparation, and assure maximum benefit and enjoyment for all attending and participating. Registration will also be held at the conference. The registration fee is $3.00.

Conference Proceedings, including all the papers and formally written discussions, will be published in book form at $3.50 per copy. The proceedings may be ordered in advance, in which case the combined price for registration and proceedings is $5.50, if ordered before March 8.

CONFERENCE COMMITTEES

Robert N. Wagner is general conference chairman and B. G. A. Skrotzki, chairman of AIEE's Power Division Committee. C. T. Hatcher is chairman of the Technical Program Committee. Other members of the Technical Program Committee are: J. A. Adams, H. F. Hoebel, M. H. McGrath, L. R. Montfort, E. I. Pollard, F. V. Smith, J. D. Wood, R. T. Woodruff, E. S. Reeser, chairman, AIEE Pittsburgh Section, and W. H. Osterle, secretary-treasurer, AIEE Pittsburgh Section. On the Registration Committee are: E. W. Brewer, chairman, and W. J. Martinbee. L. W. Tarn is chairman of the Meeting Rooms and Arrangements Committee, J. E. Lange, chairman of the Banquet Committee, and J. Z. Linsenmeyer, chairman of the Inspection Trips Committee. R. F. Lawrence is chairman of the Publicity Committee, with D. N. Reps to assist him. AIEE Headquarters representative for the conference is R. S. Gardner.

Medicine and Biology Conference Committee Asks for Papers

The 8th Annual Technical Conference on Electrical Techniques in Medicine and Biology will be held in November of 1955. The conference is sponsored by AIEE, the Institute of Radio Engineers, and the Instrument Society of America. Tentative plans call for holding the conference in Washington, D.C.

The conference serves as a meeting place for physiologists, biologists, cardiologists, radiologists, physicians, physicists, electronic, electrical, and instrument engineers. A large portion of the registration is drawn from the research groups in universities and industry.

Authors are invited to submit titles of papers for consideration by the Program Committee to E. Dale Trout, Conference Chairman, 4855 Electric Avenue, Milwaukee 1, Wis.

ASEE to Have New Executive Secretary and Editor

William Leighton Collins, engineering professor at the University of Illinois, is the new executive secretary of the American Society for Engineering Education (ASEE). Professor Collins was elected by the society's executive board to succeed Arthur Bronwell, who recently resigned when he left Northwestern University to become president of Worcester Polytechnic Institute. Professor Bronwell had served as ASEE secretary for 7 years. (See January *Electrical Engineering*, p. 84.)

The appointment of Professor Collins also means the moving of the ASEE central office from the Northwestern to the Illinois campus. Professor Collins will remain on the Illinois faculty on a half-time basis.

With the moving of the central office, plans are being made in connection with the appointment of Dr. Lisle A. Rose, another University of Illinois professor, as ASEE publications editor effective July 1. He will

succeed Professor C. E. Watson of Northwestern.

Collins has been on the Illinois faculty since 1929, and is professor of theoretical and applied mechanics. A native of Highland,

W. L. Collins

Ill., he earned both the bachelor's and master's degrees in civil engineering at Illinois.

He has been active in the ASEE since 1932, and is also active in the American Society for Testing Materials, the American Society of Civil Engineers, and the American Society for Metals. He is a member of Sigma Xi, Chi Epsilon, Mu San, and Gamma Alpha.

Dr. Rose, director of engineering information and publications and professor of general engineering at Illinois, has been on the Illinois staff since 1947. He is a native of Chicago and earned the bachelor's, master's, and doctoral degrees at the University of Chicago.

Dr. Rose has been active in the ASEE since 1940, and he has also worked with other professional groups such as the Royal Society of Arts, the Academy of Political Science, the History of Science Club, and the National Council of Teachers of English. He has been in publications work since 1930, specializing in the field of engineering.

Institute of Radio Engineers Elects Officers for 1955

John D. Ryder, dean of the School of Engineering at Michigan State College, East Lansing, Mich., has been elected president of the Institute of Radio Engineers (IRE) for 1955. He succeeds William R. Hewlett, vice-president of Hewlett-Packard Company, as head of the international society of 40,000 radio engineers and scientists.

Franz Tank, professor at the Swiss Institute of Technology, Zurich, will succeed Maurice J. H. Ponte, director of Compagnie Générale de Télegraphie Sans Fil, as IRE vice-president.

Elected as directors for the 1955–1957 term are John F. Byrne, director of engineering, Communications and Electronics Division, Motorola, Inc., Chicago, Ill., and Ernst Weber, director of the Microwave Research Institute and head of the electrical engineering department at Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Regional directors elected for 1955–1956 are as follows: Region 2 (North Central Atlantic), John N. Dyer, vice-president, Airborne Instruments Laboratory, Mineola, L.I., N. Y.; Region 4 (East Central), E. M. Boone, professor of electrical engineering, Ohio State University, Columbus, Ohio; Region 6 (Southern), Durward J. Tucker, managing director of radio station WRR, Dallas, Tex.; Region 8 (Canadian), John T. Henderson, principal research officer, National Research Council, Ottawa, Ont., Canada.

Eta Kappa Nu Achievement Award Goes to Missouri School of Mines

The Eta Kappa Nu Association's Achievement Award for 1953–54 was presented to the Gamma Theta Chapter of the Association at the School of Mines and Metallurgy, University of Missouri (Rolla). The silver plaque is given annually to one of 56 college chapters of Eta Kappa Nu which has distinguished itself in activities during the previous academic year, as well as by a high scholastic record of its student members.

Dr. Mervin J. Kelly, president of Bell Telephone Laboratories, made the presentation for the sponsors, the New York Alumni. Addresses and congratulatory messages were given at a banquet by Dr. Curtis L. Wilson, dean of the School of Mines at Rolla, and by Dr. Eric T. B. Gross, past president of Eta Kappa Nu. Dr. Gross stressed the uniqueness of this year's award as the chapter was established only three years ago. Main address was given by Dr. Kelly whose subject was, "Our Freedom—It Must Be Preserved; Your Responsibility and Mine." He emphasized the impact of the atomic age on the means for preserving our freedom.

Other guests at the banquet were: Professor Roger Nolte, on leave from Missouri School of Mines for work leading to a doctorate, and faculty advisor for the Chapter during the award year; Professor G. G. Skitek, present faculty advisor of the Chapter; and L. D. Harrison, employment manager of Southwestern Bell Telephone Company.

Prize Awards Announced for Institute and Student Papers

The Committee on Institute Prize Awards has announced the award of Institute Paper Prizes in each of the five technical classes for papers presented during the period August 1, 1953 to July 31, 1954. The papers selected for first and second prizes are as follows:

Communication Division

First Prize:

"A Step Forward in Printing Telegraphy," A. S. Benjamin and W. J. Zenner, Teletype Corporation, Chicago, Ill.

Second Prize:

"A New Portable Telegraph Transmission Measuring Set," S. I. Cory, Bell Telephone Laboratories, Inc., New York, N. Y.

General Applications Division

First Prize:

"Fundamentals of Flashing of Diesel-Electric Motors and Generators," C. A. Atwell, Westinghouse Electric Corporation, East Pittsburgh, Pa.

Second Prize:

"Rectifier Motive Power—Inductive Coordination Considerations," E. B. King, American Telephone and Telegraph Company, New York, N. Y.; K. H. Gordon, The Pennsylvania Railroad, Philadelphia, Pa.

For achievement in academic activities and scholarship, the Gamma Theta Chapter of Eta Kappa Nu Association was given a silver plaque, the Eta Kappa Nu Annual Achievement Award. The New York Alumni of the Association is sponsor of the award. Left to right: R. E. Nolte, faculty advisor of the chapter during the award year; C. L. Wilson, dean, School of Mines and Metallurgy, University of Missouri, Rolla; M. J. Kelly, president, Bell Telephone Laboratories and main speaker at award dinner; Donald Gessley, president of the chapter and vice-chairman of AIEE's Student Branch at the school; and Eric T. B. Gross, past national president of Eta Kappa Nu

and L. J. Hibbard, Westinghouse Electric Corporation, East Pittsburgh, Pa.

Industry Division

First Prize:

"Some Aspects of the Charge and Discharge Processes in Lead-Acid Storage Batteries," D. N. Craig and W. J. Hamer, National Bureau of Standards, Washington, D. C.

Second Prize:

"Atomic Film Cathode in Inert Gas Shielded Metal Arcs," W. J. Greene, Air Reduction Sales Company, Jersey City, N. J.

Power Division

First Prize:

"High Voltage Impulse Tests on Transmission Lines," C. F. Wagner, Westinghouse Electric Corporation, East Pittsburgh, Pa.; I. W. Gross, American Gas and Electric Service Corporation, New York, N. Y.; and B. L. Lloyd, Westinghouse Electric Corporation, East Pittsburgh, Pa.

Second Prize:

"Location of Series Capacitors in High Voltage Transmission Systems," S. B. Crary and L. E. Saline, General Electric Company, Schenectady, N. Y.

Science and Electronics Division

First Prize:

"The Quasi-Peak Voltmeter," C. W. Frick, General Electric Company, Schenectady, N. Y.

Second Prize:

"Effect of Electrical Discharges on the Breakdown of Solid Insulation," T. W. Dakin, H. M. Philofsky, and W. C. Divens, Westinghouse Electric Corporation, East Pittsburgh, Pa.

STUDENT PAPERS

The Committee on Prize Awards also has announced the award of the Best Student Paper Prizes for papers presented during the period August 1, 1953 to July 31, 1954. The committee has reviewed all of the papers submitted for this prize, nine reviews having been secured for each of the winning papers. The papers selected for the awards are as follows:

Best Student Paper Prize

"An Electronic Bloodcount Meter," P. L. Frommer, University of Cincinnati.

Second Prize Student Paper

"Audio Amplifier Distortion Analysis and Measurement," R. D. Keller, University of Colorado.

The Committee on Prize Awards acknowledges the valuable assistance of the technical committees and divisions and their reviewers in nominating and grading the papers.

University of Denver Branch Is Winner in District Contest

Winner in a Student Branch Membership Contest sponsored by District 6 was the Branch at the University of Denver. Rules of the contest specified that the award would be made to the District 6 Branch which had the largest ratio of national student AIEE members to total junior and senior electrical engineering students on November 15. On this basis, the University of Denver Branch achieved the outstanding score of 158 per cent, which means it has almost 100 per cent membership among juniors and seniors and excellent membership among freshmen and sophomores.

The $15.00 prize was awarded with the stipulation that it be used to buy some permanent improvement for the branch or its school. When the contest was announced, the University of Denver Branch officers decided this was their opportunity to purchase a much-needed coffee urn. They planned an all-out membership drive to be certain their branch would be the winner. After contacting all eligible students at the University during their drive, the evening before the close of the contest they called all nonmembers at their homes and urged them once again to join.

The officers of District 6 are proud of the University of Denver Branch and its membership achievement. They believe that 158 per cent is not only the best ratio in District 6, but the best in the Institute. They would like to hear from any branch, if there is one, which has a higher membership ratio. (See picture on page 163.)

Professional Engineers Plan Annual Spring Meeting

The Annual Spring Meeting of the National Society of Professional Engineers (NSPE) will be held February 18–19 in the Hotel Charlotte, Charlotte, N. C.

The two-day conference will be devoted to discussions of current problems and developments affecting professional engineers. Reports of the progress of NSPE's national programs will be made by Society officers, according to Clarence T. Shoch, Allentown, Pa., national president.

North Central Executive Committee Meeting

Delegates to the North Central Executive Committee Meeting met November 18 at the Electric Building, Omaha, Nebraska. The increase in membership in the area is accredited to the state's growing importance in electrical fields. Front row (left to right): H. A. Morgan, Chairman Denver Section; A. S. Anderson, District Vice-President, who presided; J. E. Martin, District Secretary; H. L. Meyer, Chairman, Nebraska Section. Back row (left to right): W. A. Hixson, Chairman District Committee on Student Activities; R. W. Shaw, District Vice-Chairman, AIEE Membership Committee; M. Kight, Secretary, Denver Section; H. W. Becker, Chairman, Public Relations Committee, Nebraska Section; E. J. Ballard, Secretary, Nebraska Section; O. H. Brand, Vice-Chairman, Nebraska Section; L. M. Robertson, District representative, AIEE Sections Committee; G. Wallis, Chairman Southern Colorado Subsection; R. Tario, Chairman, Black Hills Subsection

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Power Division

Committee on Transformers (*J. A. Adams, Chairman; J. R. Meador, Vice-Chairman; M. H. Pratt, Secretary*). At a meeting in New York, November 5, 1954, the committee approved a proposed revision for American Standard C57.11, Table 11.021, Limits of Temperature Rise for Transformers. The proposal is to delete reference to insulation classes and to group transformers by permissable temperature rise limits. It

(*Continued on page 165*)

West Virginia Section Honors Past Chairmen

The West Virginia Section honored its past-chairmen at a dinner meeting November 15 and presented each of them with a certificate. These are men who have served the Section since its beginning in 1940. AIEE Vice-President W. B. Morton who made the presentations is at the far left. To Mr. Morton's right are: John Vodar, Jr.; E. B. Ellerbe; L. W. Scott; E. M. Hansford; E. D. Knight; Thomas Cooper; R. F. Norwood; H. P. Masser, Sr.; and G. W. Unangst, present chairman

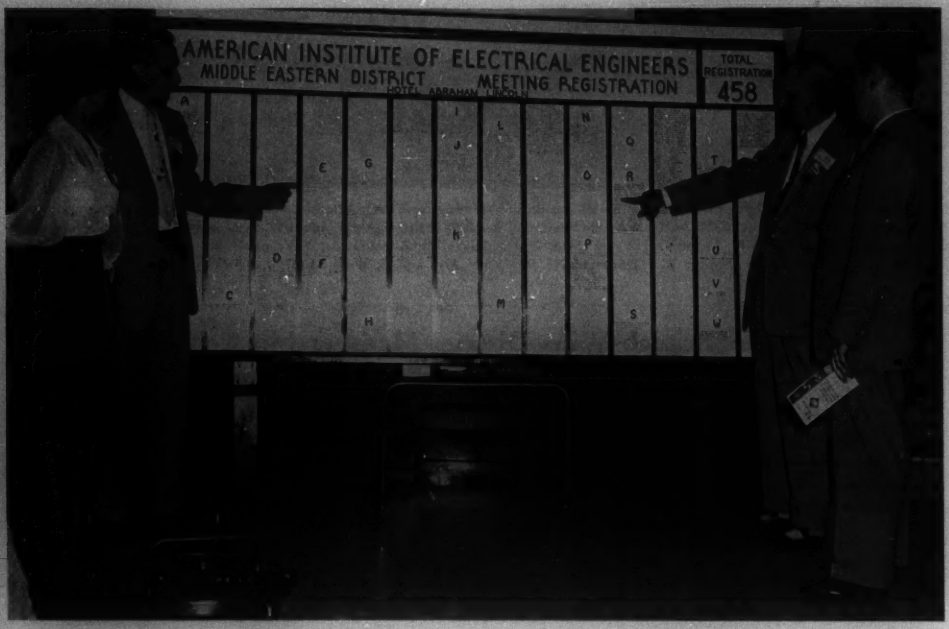
Denver Branch Wins District Membership Contest

Winner in a Student Branch Membership Contest sponsored by District 6 was the Branch at the University of Denver. AIEE Vice-President A. S. Anderson congratulates (left to right): D. J. Neale, Jr., secretary; M. F. Anderson, chairman; I. F. Davis, membership chairman; and Professor A. E. Paige, counselor. For story, see page 162

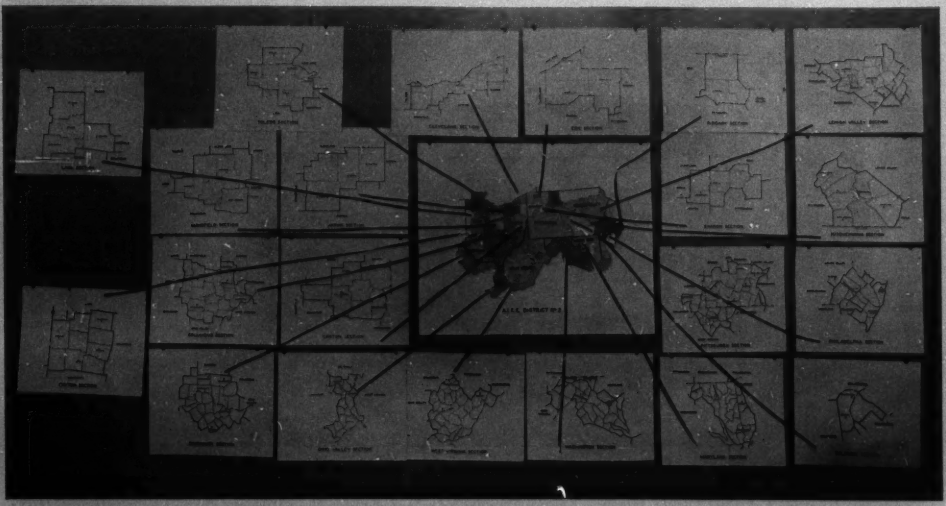
Tampa Section Committee Plans Southern District Meeting

The Executive Committee of the Tampa Section is shown above during a recent meeting at which arrangements were made for the Southern District Meeting to be held April 13–15. Seated around the table are (left to right): J. H. Rose, trips and transportation; Treasurer Don Knauss; J. Arthur Turner, member, Advisory Committee; G. L. Kenny, Jr., chairman, Finance Committee; Secretary Nat Patterson; C. J. Ellis; General Chairman I. L. Garcia; Mrs. Amy Thompson, ladies program; R. E. Raymond, smoker and social; Thurmon Doub; F. J. Campa; P. H. Nelson; J. G. Spincer, Jr.; H. Loehr, Jr.; and T. F. Thompson, Jr.

"Visual Aids" Used at District 2 Meeting



The Instant Registration Board, used by the 1954 Registration Committee of the District 2 Meeting last October, provided considerable convenience to members interested in locating friends attending the meeting. Names of registering members were immediately printed by Western Union typewriters and then posted. Also, the total registration was posted daily



This map of District 2 showing the Sections and their geographical locations was used to help orient Section Delegates at the District 2 Executive Committee Meeting, October 4, 1954, in Reading, Pa.

South Texas Section Observes 12th Anniversary

Past-chairmen of the South Texas Section were honored at the Section's 12th Anniversary Celebration. The Section was officially founded in 1943 by a small group of electrical engineers, who recognized the need for organization and affiliation with the Institute. The Section's membership is 154, including leaders in the profession who are working for industry, utilities, teaching in colleges and universities, and conducting electrical firms of their own. Left to right: past-chairmen R. A. Nicholson, A. C. Alberti, S. R. Friedsam, O. T. Lodal, I. A. Uhr, J. C. Smith, R. R. Krezdorn, G. E. Schmitt

has been submitted to the AIEE Standards Committee for further action.

The Working Group on Life of Materials has an active program on functional testing to determine the life of dry-type transformer insulations and has submitted a proposed test code to the committee. A symposium on insulation life testing is being formulated for the Summer General Meeting.

The Working Group on Audible Noise has made considerable progress on instrumentation and is starting an investigation of field application problems. Liaison with user groups is planned.

The switching surge investigation is being conducted by a liaison representative to a Working Group of the Committee on Transmission and Distribution which is also interested in this problem. A standard surge is desired which can be used as a basis for design.

Progress is being made on other projects, including: codes for insulation power-factor testing, revisions of dielectric test tables, revision of the guides for loading transformers, a test code for insulation materials for specialty transformers, a guide on insulating fluids, and an instrument transformer test code.

The West Coast Subcommittee held its first meeting in Los Angeles in June and plans to hold another in San Francisco.

Schenectady Section Visits International Paper Company

The world's largest ground-wood specialty mill was visited by Schenectady Section, December 1. This is the Hudson River Mill of the International Paper Company at Palmer, N. Y.

Supervisory personnel escorted Section members through the plant and showed them how the paper-making process progresses from the log to the paper. Members were then given a list of the various products the mill produces by O. B. Beyer, manager of the mill. Mr. Beyer also answered questions for the group, and then a film illustrating the chemical and physical changes wood pulp undergoes to become paper was also seen. After the movie, the Section was treated to lunch in the company cafeteria.

AIEE PERSONALITIES.....

F. W. Harris (AM '06, F '13, Member for Life), chief engineer of Central Maine Power Company, has had the honor of having the company's new hydroelectric generating plant at Indian Pond named for him. The station was previously informally known as the Indian Pond Station. As chief engineer, Mr. Harris has full supervision of all of the company's major construction projects. He was graduated from Rensselaer Polytechnic Institute in 1907. After graduation he joined the staff of the State Engineer of New York where he remained for the next 12 years, supervising construction of two dams on the Mohawk River and of locks, dams, and other structures forming part of the barge canal in the Schenectady, Troy, and Albany area. Later he was associated with the St. Lawrence Valley Power Company as construction engineer and superintendent of the building of three hydroelectric plants in northern New York. Mr. Harris then moved to Maine as construction engineer for Morton C. Tuttle Company on their Gulf Island construction for Central Maine Power. In 1926 he joined the staff of the New England Public Service Company where for the next 18 years he participated in the design and construction of the numerous hydroelectric projects undertaken by Central Vermont Public Service Corporation, Public Service Company of New Hampshire, and Central Maine Power Company. In 1944 he accepted the posts of agent and engineer of the Union Water Power Company and agent and engineer of the Androscoggin Reservoir Company. Together these companies own and operate the storage reservoir system on the headwaters of the Androscoggin River. In addition, the Union Water Power Company owns and operates the canal system at Lewiston. When Central Maine Power Company acquired the stock of the Union Water Power Company in 1948, Mr. Harris returned to the New England Public Service Company group ac co-ordinating engineer for Central Mains Power Company to make economic studies and plans for future increases in generating capacity. He also took over general supervision of the construction of the Flagstaff Storage Basin on the Dead River and the 60,000-kilowatt addition which was under way at Mason Station in Wiscasset. In November 1951, Mr. Harris was named chief engineer of Central Maine Power. The design and construction of the new station at Indian Pond which bears his name was executed under his direction. He is a registered professional engineer of New York, Maine, New Hampshire, and Vermont. He is a member and director of the Maine Association of Engineers and a director of the Kennebec Water Power Company. He served on AIEE's Protective Devices Committee (1914–16).

H. T. Friis (AM '20, F '41), director of research in high frequencies and electronics, Bell Telephone Laboratories, has received the Valdemar Poulsen Gold Medal. The medal, named in honor of the late Danish inventor and pioneer in electrical engineering and communications, is presented biennially by the Danish Academy of Technical Sciences. It was awarded to Dr. Friis in recognition of his notable contributions in the field of radio technology and especially his "important works on the application of short and ultra-short radio waves and,

simultaneously, on atmospherics." (See December 1954, *Electrical Engineering*, page 1133, for biography of Dr. Friis.)

V. K. Zworykin (M '22, F '45), vice-president and technical consultant and director of electronic research for the RCA Laboratories Division of Radio Corporation of America, has retired and been appointed the first honorary vice-president in the corporation's history. Dr. Zworykin received his degree of electrical engineer from the University of Petrograd in 1912. He then pursued research studies at the College de France in Paris. After wartime service with the Signal Corps of the Russian Army in World War I, he came to the United States and acquired his American citizenship immediately after the war. He obtained the degree of doctor of philosophy, at the University of Pittsburgh in 1926. He worked on the research staff of the Westinghouse Electric Corporation before joining RCA in 1930. His invention of the iconoscope, first electronic "eye" of the television camera, was followed by his development of the kinescope, the picture tube in every television set in America today. The electron microscope, developed under the direction of Dr. Zworykin, has been acclaimed as the most useful scientific tool of the 20th century. An outgrowth of television research, the electron microscope, with its ability to magnify objects up to 200,000 times, has opened vast new submicroscopic realms for exploration for science and industry. Dr. Zworykin performed distinguished service in World War II as a member of the Scientific Advisory Board to the Commanding General of the United States Army Air Forces, the Ordnance Advisory Committee on Guided Missiles, and three subcommittees of the National Defense Research Committee. In the course of his war work, he directed research resulting in the development of aircraft fire control, infrared image tubes for the famed "sniperscopes" and "snooperscopes," television, guided missiles, storage tubes, and effective improvement of radar systems. In recognition for his war work, he was awarded the Navy Certificate of Commendation, the Presidential Certificate of Merit and the War Department Certificate of Appreciation. For his outstanding peacetime contributions in radio-television and electronics, Dr. Zworykin has received many awards from scientific organizations in the United States and abroad. One of the most recent was the 1951 Medal of Honor of the Institute of Radio Engineers. Dr. Zworykin, who served for many years as director of electronic research of RCA Laboratories, was elected vice-president and technical consultant in 1947, and continued in this position until his retirement. Dr. Zworykin is the 1948 Lamme Medalist, the 1952 Edison Medalist, and has served on the following AIEE committees: Communication (1937–41); Research (1941–51).

W. H. Pickering (AM '40, M '50), professor of electrical engineering, California Institute of Technology, has been appointed director of the Jet Propulsion Laboratory of the California Institute of Technology, which operates the laboratory for the U.S. Government. Dr. Pickering, a native of New Zealand, has been on the teaching staff of the California Institute of Technology since 1936. He joined the Jet Propulsion Laboratory staff in 1944 as a section chief, and in 1951 was appointed chief of the Guided Missile Electronics Division. During World War II he served on the U. S. Air Force's Scientific Advisory Board. Previously, he had been associated with the late Dr. Robert Millikan and Dr. Victor Neher in pioneer cosmic ray studies in India, Mexico, and the Midwest. Dr. Pickering is a graduate of California Institute of Technology, receiving his B.S. degree in 1932, his M.S. in 1933, and his Ph.D. in 1936. He is also a member of the Institute of Radio Engineers. He has served on the following committees of the Institute: Electronics (1945, 1949–54); Student Branches (1947–49); Research (1949–55).

H. J. McCreary (AM '24, F '46), consultant, Automatic Electric Company, Chicago, Ill., has been initiated as a professional member of the Beta Psi chapter of Eta Kappa Nu Association, electrical engineering honor society. Mr. McCreary is a graduate of the University of Nebraska, Class of '23, with a bachelor's degree in electrical engineering and was later awarded a professional electrical engineering degree for a thesis on his invention, "The Magnetic Cross Valve." Thirty years ago he obtained a patent on cathode ray television in color. He now has 124 patents in 25 countries of which 44 are in the United States. Mr. McCreary is also a member of the Institute of Radio Engineers and a member of the Western Society of Engineers. He was secretary of the National Electronics Conference (1950–51) and a director for three years. He has been a member of AIEE's Electronics Committee (1953–55).

E. F. Peterson (AM '33, M '45), manager of marketing for General Electric's radio and television department in Syracuse, N. Y., is a recipient of the first National Electronics Conference (NEC) Award, $250. The new award may be presented annually to "the author or authors of a paper presented at a previous conference which introduced developments of a new and revolutionary character capable of significantly influencing an electronic field or of opening an avenue to a major field of electronic science or application." Peterson was co-author of, "The Lighthouse Tube; A Pioneer Ultra-High-Frequency Development" presented at the first NEC conference in 1944. It described the then new development of disk-seal tubes which played an important part in World War II radar defense.

A. G. Forster (AM '33, M '47), assistant to the technical planning officer, San Francisco Naval Shipyard, Calif., has joined Hooker Electrochemical Company. Mr. Forster, whose home town is Buffalo, was awarded the degree of bachelor of science in electrical engineering from Cornell University in 1947. Since that time he has worked for E. I. duPont de Nemours and Company at the Tonawanda, N. Y., plant, first as a project engineer for more than four years, then as an electrical engineer. Last year he was appointed electrical supervisor. He is assigned to Hooker's engineering staff.

E. A. Armstrong (AM '13, M '32, Member for Life), has been appointed consultant on public utility products and sales of the Electro-Motive Division of General Motors Corporation. Mr. Armstrong was retired by Commonwealth Edison Company of Chicago June 1. He had been manager, industrial sales, for Commonwealth Edison since 1952 when that company absorbed the Public Service Company of Northern Illinois. He was manager of industrial power sales for Public Service from 1923 to 1952. Born in Toledo, Ohio, Mr. Armstrong attended public schools in Hillsdale and Litchfield, Mich., and was graduated from Michigan State College with a B. S. degree in 1911. He was given his professional degree in electrical engineering by that institution in 1922. In the interim he worked for Continental Utilities Company, Lansing, Mich., as chief engineer of construction and operation from 1912 to 1917. During World War I he was assistant professor of physics at Michigan State. He joined Public Service at Joliet, Ill., in 1921 as power sales engineer and became manager of industrial power sales in 1923. He is a member of the Western Society of Engineers, the Great Lakes Power Club and the Petroleum Electric Power Association. He served on AIEE's General Power Applications (1930, 1938); and Industrial Power Applications Committees (1938–42).

E. L. Nelson (AM '20, M '26), technical director of the Signal Corps Engineering Laboratories, Fort Monmouth, N. J., has been appointed scientific chief of research and development for the Army Signal Corps. In his new assignment, Mr. Nelson will be responsible to the chief signal officer, for the technical direction of the research and development mission of the Army Signal Corps. This includes highly specialized scientific and engineering programs in electronics, applied physics, meteorology, photography, and many other allied fields. Prior to his appointment as technical director of the Signal Corps Engineering Laboratories on February 15, 1951, Mr. Nelson was with Bell Telephone Laboratories, New York, N. Y., engaged in development and design of military weapons systems and equipment under Army and Navy contracts. A graduate electrical engineer from Armour Institute of Technology, Chicago, Ill., Mr. Nelson joined the engineering staff of Western Electric Company in February, 1917. In November of the same year, he was granted leave of absence for an active tour of duty with the U. S. Navy, and served in England as a radio telephone specialist on anti-submarine devices, and later as radio-telephone officer with U. S. Naval headquarters in London. In 1921, he transferred to the Bell Telephone Laboratories, where he was supervisory engineer and later radio development engineer responsible for the design and development of commercial radio transmitting and receiving equipment. During World War II he was in charge of numerous military radio and radar projects of Bell Telephone Laboratories for both the Army and Navy. In 1946, he became responsible for design and development of equipment for the Bell System mobile radio telephone service and high-frequency radio transmitting and receiving equipment for installation in commercial ships. He is a

licensed professional engineer, State of New York, a member of the Institute of Navigation, and Fellow of the Institute of Radio Engineers.

R. L. Palmer, (AM '39), manager of International Business Machine's (IBM) engineering laboratory at Poughkeepsie, N. Y., has been appointed director of engineering. **J. A. Haddad,** (AM '46), technical engineer in IBM's engineering laboratory, is now director of advanced machine development. Mr. Palmer, an alumnus of Union College, became associated with IBM in 1932. He served in electrical engineering posts at Endicott, N. Y., and in 1947 was made electronics engineer at IBM's Poughkeepsie, N. Y., laboratory. He was named manager of the engineering laboratory there in 1950. Mr. Haddad, a graduate of Cornell University, joined the IBM Endicott laboratory staff in 1945. In 1946 he was assigned to Poughkeepsie and served in various engineering capacities there. He was advanced to manager of component development in 1952, and in 1953 was made manager of the Endicott engineering laboratory.

P. L. Alger (AM '17, F '30, Member for Life), consulting engineer, medium-motor induction department, General Electric Company, Schenectady, N. Y.; **V. F. Estcourt,** (M '48) general superintendent, Pacific Gas and Electric Company, San Francisco; and **R. G. Rincliffe,** (AM '42), president, Philadelphia Electric Company, Philadelphia, Pa.; have been elevated to the grade of Fellow in The American Society of Mechanical Engineers. Mr. Alger has carried the staff responsibility of the department manager of engineering for planning and co-ordination of electrical-machinery development at General Electric Company in Schenectady for more than 20 years. In his capacity as consulting engineer in the company's medium induction-motor department, he has made many contributions to the technical knowledge of synchronous and rotating induction machinery. He has developed 11 patents relating to the design of this type of machinery, and has written several papers on the subject. He is the author of the book, "The Nature of Polyphase Induction Machines," and co-author of "Induction Machines and Alternating-Current Commutator Motors." The material on electric generators in the 1938 "Encyclopedia Britannica" was contributed by him. He is a member of the Scientific Advisory Committee of the Ballistics Laboratory of the U. S. Army, and a director of the New York State Citizens Council and the Schenectady Bureau of Municipal Research. Mr. Estcourt has been active in the gas and electric fields throughout all of his professional life, except for the year following his graduation from Stanford University in 1922. In 1917 he joined the Pacific Gas and Electric Company, San Francisco, Calif., as an assistant efficiency engineer. During his career, Mr. Estcourt has accepted major responsibility for the operation of many company installations. From 1930–31 he was in charge of the development of one of the earliest 1,400-psi 750/750-F reheat stations in the nation, and the first on the Pacific Coast. He has made a major contribution to engineering in the development of very fast load pick-up characteristics and wide-range operation in the reheat station. In his present capacity, Mr. Estcourt manages the company's steam-electric generating facilities, including full consultation and approval in connection with all new steam plant design. He is the author of many technical papers related to his professional field. He is now serving on the Institute's Power Generation Committee (1953–55). Mr. Rincliffe was born in Sandusky, Ohio, in 1899. He graduated from Yale University in 1921 with an A.B. degree in chemistry, and from Massachusetts Institute of Technology in 1923 with an M.S. degree in chemical engineering. As an engineer with a public utility during the first 5 years of his professional career, he developed many improvements in installations on which he was engaged. Among these were an air-mixing device permitting the complete combustion of carbon at the burners in coke ovens, and design and installation of a cyanogen scrubber for the gas industry. In 1928, Mr. Rincliffe joined the Philadelphia Electric Company, which he now heads as president. As superintendent of production from 1928 to 1931 he made major contributions to the development of what has become known as the "reformed refinery oil gas process." During the following 7 years, until 1938, he served as superintendent of gas handling and manufacturing. He had direct charge of all gas production, pumping and storage facilities. He became successively head of the purchasing department, manager and vice-president of the electric operations department, and executive vice-president. Since his elevation to the presidency in 1952, Mr. Rincliffe has been active in the technical development of all branches of the company. He is a member of 25 technical and professional societies, and is the author of the book, "Gas Production Manual," published by his company in 1936.

G. M. Coffey, (AM '36), field engineer, sales department, Wagner Electric Corporation, St. Louis, Mo., has been appointed manager of industrial brake sales by Wagner Electric. In his new position Mr. Coffey will co-ordinate the sales of industrial crane brakes through the company's branch offices. He joined Wagner in 1936 as a student engineer following manufacturing and test experience with Emerson Electric Manufacturing Company and the A. S. Aloe Company in St. Louis, Mo. He is a graduate of Washington University, St. Louis, with a Bachelor of Science degree in electrical engineering. He is a Member of the Association of Iron and Steel Engineers.

Alexander Wust (M '50), director general of Societe d'Electricite de l'Escaut, Antwerp, Belgium, has been elected the first Affiliate, or overseas member, of the Atomic Industrial Forum, Inc. The Forum has changed its membership requirements to permit citizens and organizations of other countries having contractual arrangements with the United States affecting uranium or atomic energy information to become members. The Atomic Industrial Forum is an organization supported by industrial companies, educational institutions, labor groups, and others interested in the development of atomic energy for peaceful purposes.

N. B. Nichols (M '51), manager of Raytheon Manufacturing Company's Research Division, has been appointed an assistant vice president. Mr. Nichols, an authority in the fields of servomechanisms and electronics automation, joined the Waltham, Mass., electronics firm in 1951. He helped develop several unusual products, leading his scientific group through the investigative phases of work that eventually made possible the mass production of transistors. Mr. Nichols received degrees in physics at the Central Michigan College and the University of Michigan. During World War II, he was associated with the Radiation Laboratory of Massachusetts Institute of Technology, where he headed the servo group of the Fire Control Division. Subsequently, he became research director of the Taylor Instrument Companies, leaving in 1950 to accept a professorship at the University of Minnesota. He holds memberships in the Institute of Radio Engineers, the Instrument Society of America, the American Physical Society, the American Chemical Society, the American Society for the Advancement of Science, American Society of Mechanical Engineers, and other professional groups.

C. E. Beard (AM '51), project manager for Air Force ground radar equipment, General Electric Company, has been appointed sales manager for Air Force equipment, manufactured by General Electric's heavy military electronic equipment department in Syracuse, N. Y. A native of Asheville, N. C., he has been with General Electric since 1950, when he entered the company as a field service representative in Chicago for the commercial equipment department. Mr. Beard served with the Air Force (1942–46) as a radar development officer at the Air Proving Ground Command, Eglin Field, Fla., and as theater electronics countermeasure officer for the China-Burma-India theater. Following the war he joined the engineering staff of Radiohio, Inc., at Columbus, Ohio. He is a graduate of Ohio State University with a B.S. degree in electrical engineering, a member of the Institute of Radio Engineers (IRE), and a charter member of the IRE Professional Group on Electronics and Navigation.

H. D. Tindall (AM '37, M '47), electrical engineer, Moloney Electric Company, has been appointed manager of the Transformer Division of Federal Pacific Electric Company, Newark, N. J. His duties will include the management of Gardner Electric Manufacturing Company, San Francisco, a wholly-owned subsidiary of Federal Pacific. Mr. Tindall was associated from 1940 until his present assignment with Moloney Electric Company. Previously, he had been division engineer of Moloney's Distribution and Specialty Transformer Division, and before that, section engineer of the distribution transformer section. While employed at Moloney, Mr. Tindall was responsible for the development of the Moloney wound-core distribution transformer, the new sealed-in-nitrogen dry-type transformer lines, the revised Class "B" ventilated dry type, and the intermediate power transformer lines. During World War II, he served in the U. S. Army Signal Corps, and attained the rank of major. He was assigned to the Signal Corps Development Laboratories at Fort Monmouth, N. J., where he supervised

development of various types of communication equipment. Following his graduation from Ohio State University in 1936, Mr. Tindall joined the Wagner Electric Corporation, where he designed distribution and power transformers.

E. J. Kallevang (AM '14), vice-president in charge of engineering, system operations, and maintenance, has retired. With his retirement, Kallevang concludes 44 years of service with the electrical utility industry, 39 years of which were spent with Wisconsin Power and Light. Born at Decorah, Iowa, he attended local schools and graduated from Highland Park College with a B.S. degree in electrical engineering. He entered the employ of the DeKalb-Sycamore Electric Railway Company in 1910, and in 1915 moved to Kilbourn, Wis., where he served as chief engineer of the Southern Wisconsin Power Company, a predecessor of Wisconsin Power and Light Company. He continued as chief engineer until July 21, 1954, when he was elected vice-president in charge of engineering, system operations and maintenance.

C. C. Boesewetter (AM '44, M'52), manager testing department, Goodman Manufacturing Company, has been appointed chief engineer of Penn-Union Electric Corporation, manufacturer of conductor fittings. He will supervise all of the company's engineering activities, in addition to directing the development of new products, and construction of new and enlarged testing laboratory facilities. Mr. Boesewetter, is an engineering graduate of the Milwaukee School of Engineering and the University of Wisconsin. As manager of the engineering testing laboratory at Goodman Manufacturing Company he was responsible for research, design, test, and development of control apparatus, shunts, switches, conductor fittings, and similar accessories. He is a member of the AIEE, the American Mining Congress, and is a registered professional engineer.

T. M. Robertson (AM '52), engineer, Vitro Corporation of America, has been named assistant department head at the Silver Spring Laboratory of Vitro. Mr. Robertson came to Vitro in 1947 from the Farnsworth Radio and Television Corporation. During the war he served in the Signal Corps. He graduated from the University of Illinois in 1943 with a degree in electrical engineering, and is a member of the Institute of Radio Engineers, as well as AIEE.

J. W. Brain (AM '50), electrical engineer in the firm of Lutz and May, consulting engineers, Kansas City, Mo., has become one of the four partners comprising the newly organized Lutz and May Company. A native Missourian, Mr. Brain was graduated with a degree in electrical engineering in June, 1937. An additional training course was received through Westinghouse Electric 1937–38. From 1938–41, Mr. Brain was employed by Black and Veatch. In 1941, he entered the Signal Corps, and was discharged in 1946 with the rank of Captain. He returned to electrical engineering with Black and Veatch until 1949 when he joined the firm of Lutz and May where he became head of the electrical department.

R. C. Blatt (M '39), associate editor, *Electrical World*, McGraw Hill Publishing Company, has been appointed as director of publications for the American Society of Refrigerating Engineers. Prior to his editorship of *Electrical World*, he was editor of *Airports and Air Carriers*, a Haire Publication, and technical editor of Conover-Mast's *Aviation Maintenance and Operations*. Prior to that, he was chief airport lighting engineer for the Civil Aeronautics Administration in Washington, D.C. He served as electrical engineer for the municipal architect of the District of Columbia from 1929 to 1941, and earlier was illuminating engineer for the Potomac Electric Power Company in the same city. During this period he also served as an electrical consulting engineer for many of the leading architects in Washington, D.C. Mr. Blatt is a registered professional engineer in New York State and is a member of many professional societies including: AIEE, the Illuminating Engineering Society, National Society of Professional Engineers, and Aviation Writers Association.

G. D. Linsey (AM '53), formerly on General Electric Company's rotational training program, is now doing development work in instrumentation with General Electric's technical section, engineering department, at the Hanford Atomic Installation near Richland, Wash. (The plant is operated by the company's Hanford Atomic Products Operation for the Atomic Energy Commission.) He is a graduate of the University of Wisconsin where he received his B.S. in electrical engineering in February, 1953.

L. E. Emerich (AM '24), manager of the Market Development Division of Leeds and Northrup Company, has been appointed director of marketing and a member of the new executive committee. Emerich graduated from Carnegie Institute of Technology in 1922 with the degree of Bachelor of Science. He joined Leeds and Northrup in 1922. He is a member of Instrument Society of America.

D. D. Knowles (AM '27, M '39), vice-president's staff, Westinghouse Electric Corporation, Elmira, N. Y., has been named manager of product administration. Mr. Knowles, prominent in the electronic tube field, is holder of the John Scott Medal for meritorious inventions in gaseous conduction tubes. He holds more than 80 patents issued on electronic tubes, circuits, and oil-burner controls. He joined Westinghouse at East Pittsburgh in 1923, following his graduation from Baldwin-Wallace College with the degrees of Bachelor of Arts and Bachelor of Science, and from Purdue University with a degree in electrical engineering. He served at the research laboratories until 1937, when he left Westinghouse to become director of research and development for the Raytheon Corporation. He joined Westinghouse at the Lamp Division in 1939 and was transferred to the Electronic Tube Division here in 1952. He is on AIEE's Electronics Committee (1951–55).

C. T. Kastner (AM '50), sales engineer, General Electric Company, Pittsfield, Mass., has been appointed sales manager for the company's medium transformer plant at Rome, Ga. Mr. Kastner will be responsible for both the sales and promotion of medium transformers, the power transformers in the range of ratings 501-5,000-kva single-phase, 501-10,000-kva 3-phase, 69-kv and below. A graduate of Yale University with an M.E. degree in 1946, Mr. Kastner previously attended schools in Memphis, Tenn. He joined General Electric in July, 1946, on the company's test program. Following Lynn and Schenectady assignments, he transferred to power transformer sales in Pittsfield. In January 1952, he was appointed supervisor of traveling specialists and later supervisor of medium transformer sales.

T. E. Curtis (AM '39, M '45), chief engineer of the Electrical Division of Southern States Equipment Corporation, has been appointed chief engineer of protective devices and power switching equipment for A. B. Chance Company, Centralia, Mo. Mr. Curtis has been with Southern States Equipment Corporation for the past 15 years. He had previously been employed by the Tennessee Electric Power Company and the Alabama State Highway Department. An electrical engineering graduate of Alabama Polytechnic Institute, he has been active in both the NEMA and AIEE. He is a member of AIEE's Subcommittee for Preparation of Standards on Switches, Fuses and Insulators, a subcommittee of the main Committee on Switchgear.

H. V. Nye (AM '20, F '40, Member for Life), has retired as consulting engineer for switchgear equipment at Allis-Chalmers Manufacturing Company. A veteran of 48 years of service with Allis-Chalmers, Nye joined the company in 1906 after graduation as an electrical engineer from Iowa State College. For many years he was engineer-in-charge of switchgear design before being appointed consulting engineer in 1949.

B. M. Wolframm (AM '53), senior research engineer, North American Aviation Company, Downey, Calif., has recently been appointed chief engineer of the Magnetic Research Corporation, El Segundo, Calif.

Victor Harris (M '48), chief, technical liaison and reports office, Kellex Corporation, is assistant department head of the Silver Spring Laboratory of Vitro Laboratories, according to an announcement made by Woodman Perine, director. Vitro Laboratories is a division of the Vitro Corporation of America, New York. Before joining the company in 1946, he was connected with the Applied Physics Laboratory of Johns Hopkins University. He has also done engineering work for the U. S. Navy Bureau of Ships, the Division of War Research at Columbia University, and the Douglas Aircraft Corporation. He attended the University of California and has served on AIEE's Electronics Committee (1951–55).

P. E. Shaad (AM '34, M '46), electrical engineer, Sacramento Municipal Utility District, Sacramento, Calif., is now assistant general manager and assistant chief engineer of the Sacramento Municipal Utility District. He graduated from the University of Kansas with honors in engineering and was previously employed by both the General Electric Company and the Hawaiian Electric Company.

G. W. Dunlap, (AM '35, F '48), assistant division engineer, High Voltage and Nucleonics Division, General Engineering Laboratory, General Electric Company, Schenectady, N. Y., is AIEE representative on the Nuclear Congress Program Committee of Engineers Joint Council, national organization of nuclear engineers. He is also on the Executive Committee of the Nuclear Engineering Division of the American Institute of Chemical Engineers. Dunlap served on AIEE's Committee on Nucleonics (1948–52, chairman 1952–54, 1955); Science and Electronics Division (1952–54); Electrical Techniques in Medicine (1951–55); and Instruments and Measurements (1947–51).

OBITUARIES

Walter D. Steele (AM '00, Member for Life), associated with Benjamin Electric Manufacturing Company, Des Plaines, Ill., since its founding in 1901, died December 9. With his associates he organized Benjamin Electric in 1901, and in 1907 became actively connected with it as vice-president in charge of sales and manufacturing activities, and served as president from 1928 until 1954. In 1954 he retired from active business in favor of a consulting capacity. During his career he was a leader in electrical industry affairs and in 1952 was awarded the first 60-year medal for continuous and devoted service to the entire electrical industry by the National Electrical Manufacturers Association. Mr. Steele was born in Keokuk, Iowa, and graduated from Iowa State College in 1891. After graduation he was associated with the Cast Iron Pipe Works of Cincinnati. Then, in 1892, he joined the Brush Electric Company as an engineer in the Chicago office. On January, 1, 1894, he became engineer in charge of outside construction for the municipal power plant of the City of Detroit, later becoming assistant city electrician, and in 1896, city electrician and superintendent in charge of the operation of this plant. During this time he established the first municipal inspection department under an ordinance of the City of Detroit and administered this department as part of his duties as city electrician. Mr. Steele joined Westinghouse, Church, Kerr and Company in New York in 1900. He had charge of design, specification and construction of a wide variety of projects. Included in these projects were some "firsts" in the electrical industry. One of these was the first conversion of a large machine shop from directly applied steam power to the use of electric motors. This was the conversion of the Santa Fe shops at Topeka, Kansas.

Paul William Kirkpatrick (AM '28), general engineering personnel supervisor of the Mountain States Telephone and Telegraph Company, Denver, Colorado, died recently while on a business trip in El Paso, Texas. Mr. Kirkpatrick was born in Smith Center, Kansas, May 19, 1899, and moved to Colorado in 1911. He received his B. S. degree in electrical engineering from the University of Colorado in 1923. He was a member of Eta Kappa Nu honorary electrical engineering fraternity. After graduation, he was employed by Westinghouse Electric Corporation in Pittsburgh and was assigned to the Denver office in 1925. In 1928 he joined H. S. Sands, consulting engineering firm. In 1929 Mr. Kirkpatrick entered the communication field as an equipment engineer in the general engineering department of the Mountain States Telephone and Telegraph Company. He served in various assignments in that department until his appointment as methods engineer. In January, 1954, he became general engineering personnel supervisor. Mr. Kirkpatrick was active in the Denver Section of AIEE and served several years as editor of the Section publication, *Dods*. He was also a member of the Colorado Society of Engineers.

Aubrey Evelyn Beattie (M '47), engineering manager for Gulf States Utilities Company, died suddenly November 29. Mr. Beattie had been associated with Gulf States and predecessor firms since 1922. An engineering graduate of Nova Scotia Technical College, he went to work for Stone and Webster Engineering Corporation at Boston in 1922. He was subsequently transferred to Cape Breton Electric Company in Nova Scotia where he remained until 1925, when he moved to Beaumont, Texas. There he assumed a post as distribution engineer with the old Eastern Texas Electric Company, a Gulf States predecessor. Shortly thereafter he was made superintendent of transmission and distribution. Transferred to Lake Charles, La., in 1935, as superintendent of transmission and distribution for the Lake Charles Division, he remained there until 1942. He returned to Beaumont in that year in the system engineering department and in 1950 was promoted to his recent position of engineering manager. Mr. Beattie was active on the AIEE Transmission and Distribution Committee (1949–50).

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of December 16, 1954, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Adams, E. M., application engr., Westinghouse Electric Corp., Providence, R. I.
Bailey, E. A., application engr., I-T-E Circuit Breaker Co., Philadelphia, Pa.
Baumann, F. W., manager, engg. subsection, General Electric Co., Schenectady, N. Y.
Boyle, M. V., electrical engineer, General Electric Co., Philadelphia, Pa.
Bryan, J. R., Jr., street lighting engineer, The Toledo Edison Co., Toledo, Ohio.
Decker, W. J., engineer, Commonwealth Edison Co., Chicago, Ill.
Dickinson, R. W., proposition engineer, General Electric Co., Pittsfield, Mass.
Dingenthal, J., electrical engineer, Atlantic Div., U.S. Corps of Engineers, New York, N. Y.
Fishburne, F. J., transmission supt., Charleston Div. South Carolina Electric & Gas Co., Charleston, S. C.
Grauer, C. T., senior electrical engineer, radiation lab., University of California, Livermore, Calif.
Gubanc, R. D., electrical engineer, Clark Controller Co., Cleveland, Ohio.
Hale, W. O., consulting & application engineer, Westinghouse Electric Corp., Hartford, Conn.
Haselton, F. W., product sales mgr., Federal Electric Products Co., Hartford, Conn.
Huston, E. F., engineer, Ohio Brass Co., Mansfield, Ohio.
Jarrett, E. I., senior engineer, Duquesne Light Co., Pittsburgh, Pa.
Krause, C. E., assistant relay engineer, Illinois Power Co., Decatur, Ill.
Lantz, F. L., electrical engineer, Giffels & Vallet, Inc., Detroit, Mich.
Lauber, T. S., engineer, General Electric Co., Pittsfield, Mass.
Leemon, W., engineer, The Ohio Bell Telephone Co., Cleveland, Ohio.
Leithold, K. K., associate electrical engineer, University of California, Los Angeles, Calif.
Lewis, W. B., assistant prof. of elec. engg., University of Oklahoma, Norman, Okla.
Marsh, W. D., application engineer, General Electric Co., Schenectady, N. Y.
Mather, G. H., electrical engineer, Colmar plant, Link-Belt Co., Colmar, Pa.
Meyerend, F. M., electrical engineer, Bridge Div., John A. Roebling's Sons Corp., Trenton, N. J.
Milligen, Bert H., measurements foreman, Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Mollerhoj, J. S., associate director, a/S Northern Cable & Wire Works, Copenhagen, Denmark
Norton, R. S., chief engineer, special devices, Infra Electronic Corp., Roseland, N. J.
Philpot, C. P., associate professor & head, electrical engineering dept., Tennessee Polytechnic Institute, Cookeville, Tenn.
Schwartz, D. E., engineer, Navy Dept., Buser, Washington, D. C.
Slemon, G. R., asst. professor of electrical engineering, Nova Scotia Technical College, Halifax, N. S.
Tatman, A., electrical engineer, Hi-Voltage Equipment Co., Cleveland, Ohio
Tucker, E. H., electrical engineer, Newment Mining Corp., New York, N. Y.
Wendt, R. R., senior engineer, Bendix Aviation Corp., Mishawaka, Ind.
Whitwell, O. D., manager, electronics dept., Clark Controller Co., Cleveland, Ohio
Yates, F. A., manager of commercial engg., Finderne plant, Diehl Mfg. Co., Sommerville, N. J.

35 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before February 25, 1955, or April 25, 1955, if the applicant resides outside of the United States, Canada, or Mexico.

To the Grade of Member

Ali, S. N., Punjab Public Works Dept., Electricity Branch, Lahore, Punjab, Pakistan.
Byrd, P. R., F. H. McGraw & Co., Paducah, Ky.
Eager, M., Massachusetts Institute of Technology, Cambridge, Mass.
Hall, J. R., Continental Electronics Mfg. Co., Dallas, Texas
Hamilton, W. H., Westinghouse Electric Corp., Pittsburgh, Pa.
Kiser, W. L., Federal Communications Commission, New York, N. Y.
Menon, K. B., (Indian Institute of Technology, Kharagpur, India), Metropolitan Vickers Electrical Co. Ltd., Manchester, England
Seth, V. D., Electricity Department, Uttar Pradesh, Lucknow, India
Vassil, P. N., (re-election), Department of Army Corps of Engineers, Washington, D. C.

9 to grade of Member

OF CURRENT INTEREST

Unique Mechanism Docks Planes at New York International Airport

The Whiting Loadair is a mechanical device which docks a commercial airplane by moving it sideways to a covered pier or dock. For the first time passengers will be able to board a plane directly from an airport terminal building without being exposed to the weather. Baggage will be handled for the first time from plane to baggage claim area by means of conveyors directly.

An American Airlines DC-7 is shown on the Whiting Loadair, which is moving it on cars along tracks to a point where the plane's door will be flush with the entrance to the terminal

The aircraft taxis into position, placing its wheels on dollies, and stops its engines. The Loadair winch then moves the dollies on rails so that the aircraft is moved sideways about 90 feet in less than a minute until its door is flush with the entrance to the Loadair dock. The operation is controlled by two push bottoms (one at the dock and one on the ramp), and there are limit switches which automatically stop the aircraft at the proper point. Conversely, a departing aircraft is moved sideways away from the dock to the point where it starts its engines and taxis off the dollies.

The Whiting Corporation of Harvey, Ill., developed and manufactures the patented Loadair system. The first installation of the system anywhere in the United States is at the New York International Airport. The equipment installed includes the Whiting Loadair machinery which will handle all makes and models of United States transport aircraft presently using New York International Airport. It is powered by a 20-hp main-drive motor which enables the device to move a 75-ton craft 90 feet in 40 seconds for an electrical cost of less than $1^1/_2$ cent per operation. All electric controls and motors were supplied by Westinghouse.

The baggage and cargo-handling conveyors connect the various cargo hatches of the aircraft directly to the baggage claim area. They transport the baggage at a rate of 150 feet per minute. These conveyors were designed, manufactured, and supplied by Stephens-Adamson Company of Aurora, Ill. The pier or dock building is a specially-designed building from which the passenger steps directly into the aircraft. This is 94 by 10 feet of steel construction. The outer or plane end has two stories. The upper story is used for boarding the 4-engine-type aircraft and for cabin servicing use. The lower story is used for boarding the smaller twin-engine aircraft. The lower level is also used for baggage reclaim and ticket check-in prior to boarding the aircraft.

Future Meetings of Other Societies

Society of the Plastics Industry, Inc. Tenth Annual Reinforced Plastics Division Conference. February 8–10, 1955, Hotel Statler, Los Angeles, Calif.

Institute of Radio Engineers. 7th Annual Southwestern Conference. February 10–12, 1955, Baker Hotel, Dallas, Tex.

Pennsylvania Electric Association, Winter Meeting of the Transmission and Distribution Committee. February 10–11, 1955, Hotel Roosevelt, Pittsburgh, Pa.

National Association of Purchasing Agents, Public Utility Buyers' Group, 24th Annual Mid-Winter Conference. February 13–14, 1955, Shamrock Hotel, Houston, Tex.

National Rural Electric Cooperative Association, 13th Annual Meeting. February 14–17, 1955, Convention Hall, Atlantic City, N. J.

Pennsylvania Electric Association, Winter Meeting of the Electrical Equipment Committee. February 17–18 1955, Benjamin Franklin Hotel, Philadelphia, Pa.

National Society of Professional Engineers, Annual Spring Meeting. February 18–19, 1955, Hotel Charlotte, Charlotte, N. C.

Society of Plastics Industry, Inc., Thirteenth Annual Canadian Conference. February 22–23, 1955, Hotel London, London, Ont., Canada

Instrument Society of America, Annual Winter Conference of the New York Section. February 23, 1955 Hotel Statler, New York, N. Y.

Pennsylvania Electric Association, Winter Meeting of the System Planning Committee. February 28–March 1, 1955, Warwick Hotel, Philadelphia, Pa.

National Association of Corrosion Engineers, Eleventh Annual Conference and Exhibition, March 7–11, 1955, Palmer House, Chicago, Ill.

Oklahoma Agriculture and Mining College, Symposium on Electromagnetic Relays. March 9–11, 1955, Stillwater, Okla.

National Electrical Manufacturers Association, Meeting. March 13–18, 1955, Edgewater Beach Hotel, Chicago, Ill.

American Society of Tool Engineers, 23rd Annual Meeting. March 14–18, 1955, Los Angeles, Calif.

Association of Supervising Electrical Engineers, Fourth Electrical Engineers' Exhibition. March 15–19, 1955, Earls Court, London, England.

Southeastern Electrical Exchange, Annual Meeting. March 21–23, 1955, Boca Raton Hotel, Boca Raton, Fla.

American Society for Metals, Western Metal Expo and Congress. March 28–April 1, 1955, Pan-Pacific Auditorium, Los Angeles, Calif.

Society for Nondestructive Testing, Ninth Western Metal Congress. March 28–April 1, 1955, Hotel Ambassador, Los Angeles, Calif.

Illinois Institute of Technology, 17th Annual American Power Conference. March 30–April 1, 1955, Sherman Hotel, Chicago, Ill.

Direct Amplification of Light Achieved by Newly Developed Phosphor Cell

Another step forward in scientific progress was made in the General Electric Company's research laboratory with the discovery of a light amplifier without the use of electron tubes. An experimental phosphor screen, across which an electric field was set up, emitted ten times the amount of light than was incident upon it.

An ordinary lantern-slide projector was used to throw the image of a picture on a 4-inch screen, the light energy coming from an ultraviolet source. The picture was a regular photographic slide, shown in Fig. 1. As the direct voltage across the screen was raised to the order of 100 volts, the picture became brighter in the way usually achieved by increasing the intensity of the projector light or by opening the lens aperture (Fig. 2). The difference in intensity before and after the voltage was raised is illustrated in Fig. 1. During the over-all brightening of the image, the contrast was virtually unchanged, showing proportional amplification of the image.

As shown in the schematic diagram of Fig. 3, the structure of the screen consists of a phosphor (zinc-sulphide) film between plane parallel electrodes, one of which is transparent. Although this phosphor exhibits negligible light emission under the influence of only an electric field, its light output is increased proportionally when the field is increased and light impinges upon it.

Fig. 1. These two photographs were printed simultaneously, without any special photographic manipulation, from negatives made consecutively on a roll of 35-mm film with the same camera, using the same lens, lens opening, and exposure time. The picture was projected on the small screen with a lantern-slide projector, and neither the light source nor the lens opening of the projector were altered between the two exposures reproduced here. The brightness increase in the left picture was produced by the method of direct light amplification

Fig. 2. Slide projector at the left throws image on light-amplifying screen held by D. A. Cusano (left), who is credited with creating the light-amplifying phosphor by Dr. F. E. Williams (right)

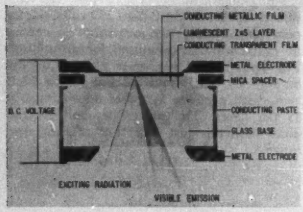


Fig. 3. Schematic diagram shows the elements of the special phosphor cell developed by scientists at the General Electric Research Laboratory

It was brought out by Dr. F. E. Williams, head of the light generation studies at General Electric's research laboratory, that the frequency of the incident light energy on the particular phosphor in the screen affected the frequency of the light output. For instance, when ultraviolet light was the source, the zinc-sulphide screen fluoresced yellow.

Dr. C. G. Suits, General Electric's vice-president and director of research, stated that although this new phenomenon may have great importance in the future of television, X-ray fluoroscopy, "seeing-in-the-dark" devices, and other developments, no immediate application should be anticipated. D. A. Cusano is credited with the creation of the light-amplifying phosphor.

Johns Hopkins University Building to Be Named for Dr. Ames

The new engineering building of The Johns Hopkins University will be named Ames Hall in honor of former President Joseph Sweetman Ames, by action of the Board of Trustees, it has been announced by President Lowell J. Reed.

The formal dedication of the building, which cost $1^1/_2$-million dollars in state-appropriated funds, will be held sometime in the spring.

Dr. Ames, a noted physicist who died in 1943 at the age of 78, was the fourth president of the university. As a student, professor of physics, dean, provost, and president, he was identified with Johns Hopkins from 1883 until 1935, when he retired, becoming president emeritus.

Although known for a brilliant career as an educator, he was also noted for his research in the aeronautical field. He was chairman from 1927 to 1939 of the National Advisory Committee for Aeronautics, of which he was a member from 1917 to 1941. At the Langley Memorial Laboratory, Langley Field, Va., he developed many devices for safety and efficiency in all types of aircraft, for which he received the Langley Gold Medal of the Smithsonian Institution in 1935. That same year he also was given the Sylvanus Reed Award from the Institute of Aeronautical Sciences. Dr. Ames was also a member of the National Research Council, the National Academy of Sciences, an honorary member of the Royal Institution of Great Britain, a fellow of the American Academy of Arts and Science and of the American Physical Society.

The new engineering building, the cornerstone-laying of which took place last May, completes the group of major buildings on the main quadrangle of Johns Hopkins' campus. Located adjacent to the original buildings, the first of which was designed in 1913, it follows their style of Georgian architecture.

Generating Unit Exploded at Ridgeland Station

The low-pressure turbine of a cross-compound generating unit with a capability of 160,000 kw exploded at Commonwealth Edison Company's Ridgeland Station, apparently due to metal failure in the turbine spindle shaft. The basic cause of this failure has not yet been determined.

The unit (# 4) is one of four of the same size in this station. Flying pieces of metal damaged the other three units, and the station was completely shut down. The accident occurred at 11:19 p.m., December 19, 1954. The other three units, however, were restored to service within 50 hours.

Ridgeland Station is the newest on the Edison system. It is located on the Chicago Sanitary and Ship Canal about 2 miles west of the city limits. Construction on this station was begun in 1948, and the four units had a total net capability of 640,000 kw. Unit 4, built by Allis-Chalmers Manufacturing Company, had been in commercial operation since August 1954, had passed every normal test, and had given no previous evidence of trouble.

At the time of the accident, the unit had been out of service for 2 days for cleaning of the boiler. It is a regular practice after a turbine outage to recheck the overspeed trip before placing the machine back in service. In this case, it meant separately checking the overspeed trip on both the high-pressure and low-pressure elements of the turbine.

The low-pressure element, with a normal speed of 1,800 rpm, had been given its overspeed check and had tripped within the 10 per cent limit. The high-pressure element was being brought up for its overspeed check when the failure occurred.

There were six men on the floor at the time engaged in this operation. Five were Edison men and one the manufacturer's representative. Two Edison men were killed by flying metal and the four other men suffered either broken bones or shock. No one else either inside or outside the station received injuries but three were treated for shock.

The center section of the spindle shaft, approximately 7 feet in diameter and 4 feet long, broke into a number of pieces which were thrown out of the machine along with much of the turbine casing. One section weighing several tons went through the roof of the building and landed in the coal pile to the west of the station building. Another, of comparable size, traveled east and ripped open the tailpipe on the Unit 1 condenser, 300 feet away. Other pieces cut through the cross-over pipes between the intermediate- and low-pressure elements of both Unit 2 and Unit 3. One piece also cracked the

Turbine Room at Ridgeland Station, showing wrecked low-pressure Unit 4 and damage to other units

Close-up view of low-pressure Unit 4 at Ridgeland Station. Center section of spindle with eight rows of blades is missing. Stub shafts and double exhaust blades remain in place

casing on the low-pressure element of Unit 3. Miscellaneous damage was done throughout the turbine room by other flying metal. The most extensive building damage was done to the roof structure.

At the time the accident occurred, the other three units at Ridgeland were carrying a load of 460,000 kw out of a total system load of 1,850,000 kw. System load was dropping rapidly at the time, and other units were able to respond to the demand without material loss in frequency or other disturbances. The tie-lines to the neighboring systems to the east, which normally carry no load at this time of the day, picked up 190,000 kw. This part of the load was transferred to Chicago area stations within a few minutes. A most difficult problem was the picking up of the Monday morning daytime and evening loads with 640,000 kw of Ridgeland capacity out of service. There was a good possibility that this load would be the all-time system peak. Over 600 large customers were called on to reduce their demands by 25 per cent, and the general public was requested to co-operate by reducing load wherever possible. Purchases from other companies over interconnections were made to the extent of approximately 200,000 kw. With these measures the system load was carried successfully.

A remarkable repair job was done within a very short time. A new tailpipe 12 feet long, 5 feet in diameter, and made of 1/2-inch steel was fabricated and welded into place in order to restore Unit 1 to service. The cross-over pipes on Unit 2 and Unit 3 had both been cut severely, and new sections of pipe had to be welded into place where the damage was done. The casing of Unit 3 had been cracked by flying steel. The crack was sealed by the metal-lock method and a section of steel plate was riveted on for added strength. The hydrogen control panel for Unit 3 had been wrecked and was replaced by a panel from Will County Station, now under construction.

While the units were actually back in service within 50 hours, the work of replacing roof trusses, precast concrete roof slabs, and other work in the station still continues.

Investigations are being made to determine the basic cause of the spindle-shaft failure. The spindle design is not unusual. The forging itself was subjected to all well-established factory tests, including ultrasonic and tests associated with interior boring. A large part of the damage is expected to be covered by the manufacturer's warranty and by the company's insurance.

Modern Electronic Ovens Provide Speed in Cooking

Two commercial models of the Raytheon Manufacturing Company's (Waltham, Mass.) "Radarange" microwave oven are currently in production. Both are single-package systems housed in stainless-steel cabinets.

Heating is accomplished by microwave energy at 2,450 megacycles, generated by using *QK-390* continuous-wave, air-cooled magnetrons. Two magnetrons are used in the larger unit to produce a maximum of 1,600 watts of microwave power for heating purposes, while one magnetron in the smaller unit produces a maximum of 800 watts. The microwave energy in both cases is directly coupled to the oven cavity, where it is confined by the metal walls and a door designed with appropriate chokes.

Except for the magnetrons, the electric equipment in the Radarange consists only of power supply and control equipment. The only tubes besides the magnetrons are the rectifier tubes in the power supply. The power supply furnishes 320 milliamperes at 5,000 volts to each magnetron in the form of pulsating direct current, which is derived from the line supply using a transformer and full-wave bridge rectifier. The rectified voltage is applied directly to the magnetron without filtering, as magnetrons are more stable with this sort of supply than with pure direct current.

Maintenance has been simplified in the new commercial-model Raytheon "Radarange" oven through better designed circuitry, and an improved long-lived air-cooled magnetron

As magnetrons are essentially constant voltage devices like gas voltage-regulator tubes and will draw widely fluctuating amounts of current with very small changes in voltage, some means of current control is required. This control is accomplished very simply with a saturable reactor circuit in series with the primary of the high-voltage transformer. Using this reactor, the magnetron current, and thus the cooking speed, is held virtually constant for changes in line voltage of +10 or −5 per cent. The reactor is also used to provide lower oven heats by reducing the magnetron current. This method is a particularly convenient way to control heat as all switching can be done in the low-current control circuit rather than in the power circuit.

As the magnetrons and the mercury rectifiers generate h-f hash, filters are built into the range on the magnetrons and in the incoming power lines, to reduce the radiated and conducted noise to a point where it is free from objectionable interference.

The rest of the circuit is a straightforward control circuit with interlocks to provide protection from high voltage and to shut off the radiation if the oven door is opened. Power is provided for exhausting steam from the oven and cooling the magnetrons and other components. Cooling in itself is an important problem, and considerable care has been taken to insure long life by running the electric components cool.

Radarange microwave ovens are designed to operate on 208 to 230 volts, single-phase, 60 cycles; the neutral wire carries no current and can be used for grounding. The large model consumes about 1.02 kw on standby and about 5.3 kw on the high heat, with a power factor of approximately 85 per cent. The power demand for the small model is just half that of the large range.

Private Industry Assisted in Defense Planning

The survival of a company today demands that it plan how to reduce the effects of an enemy attack, how to deal with espionage and sabotage, and how to resume production quickly after an attack. This is an important job for management today.

The subject is presently receiving the concentrated thought and attention of the Business and Defense Services Administration (BDSA), United States Department of Commerce. In order to stimulate management to do what they can with what they have, a booklet, "Job for Management," has been prepared with the assistance of the Industry Task Group, which includes representatives from a number of private industrial firms.

In addition, much help is available to those companies that will undertake the job of defense planning. Plans and the experience of other companies are available;

factual data on target areas, the destructive power of various weapons, the vulnerability of structures, and other needed background facts are obtainable. BDSA is set up to provide the necessary information, to act as a clearing house for ideas, and to bring companies in contact with people in government or industry who may be of assistance. Many companies have found the counsel and assistance a good starting point. Contact BDSA if any information or assistance is needed.

Conference on Photoconductivity Was Held in Atlantic City

The first scientific meeting devoted entirely to the subject of photoconductivity was held at the Senator Hotel in Atlantic City, N. J., recently. The sponsoring agencies were the Office of Naval Research, the University of Pennsylvania, and the Radio Corporation of America. Limited space and the desire to promote discussion among those active in the field, made it necessary to restrict attendance to about 140 persons.

The program included 30 invited and contributed papers, covering nearly all aspects of photoconductivity. The topics receiving the greatest emphasis were photon absorption processes, electron processes, the phenomenological theory of photoconductivity, and photoconductive materials. The final session was devoted to current research on photoconductivity in indium antimonide, germanium, tellurium, lead sulphide films and single crystals, and lead telluride films.

The papers presented at this conference, together with significant comments from the floor, will be published by John Wiley and Sons, New York, N. Y., under the auspices of the American Institute of Physics, and is expected to appear next summer.

Fermi Received First Special AEC Award

The late Enrico Fermi, who had been professor of physics at the Institute for Nuclear Studies, University of Chicago, Chicago, Ill., was named as the recipient of the first special award by the United States Atomic Energy Commission.

The Atomic Energy Act of 1954 authorizes such awards for "especially meritorious contributions for the development, use, or control of atomic energy." The award to Dr. Fermi, which was recommended by the General Advisory Committee and approved by President Eisenhower, is for $25,000. The award was accompanied by a citation noting Dr. Fermi's contributions to basic neutron physics and the achievement of the controlled nuclear chain reaction.

Dr. Fermi's accomplishments in physics and in particular his contributions to the development of atomic energy have been of tremendous importance. The Fermi-Dirac particle statistics, the theory of beta-decay, the Fermi-Thomas model of the atom, neutron induced radioactivity, and a theory of the origin of cosmic rays are among his experimental and theoretical works. He had been awarded, among other honors, the Nobel Prize, and had been president of the American Physical Society.

Precision Glass Screens Designed for Cathode Ray Tubes

The successful manufacture of 300-mesh precision glass screens containing over 200,000 square holes so small they cannot be threaded by a human hair is announced by Corning Glass Works, Corning, N. Y.

Currently being supplied for use as part of a cathode ray tube, the precision screens can now be made more accurately than ever before.

Prior to the use of glass, these components were usually made of copper by an electroplating process. The new glass screens offer sharper definition and at the same time simplify manufacturing and conductivity problems encountered with other materials.

The screens are currently being supplied as small squares with approximately $2^1/_4$ square inches of screen area containing 90,000 accurately spaced holes per square inch. However, the unusual manufacturing method is not limited to these sizes or shapes or to 300 mesh.

The screens are made from Corning's "fotoform" glass. Fotoform is a new photosensitive glass that can be formed and cut with photographic precision. After the screen has been formed, the glass is converted to "fotoceram", a material 2 to 3 times stronger than the parent glass. The process can be adapted for partial or complete cutting of glass in any pattern that can be reproduced photographically.

Summer Sessions in Statistics Held at University of Florida

The University of Florida, North Carolina State College, Virginia Polytechnic Institute, and the Southern Regional Education Board are jointly sponsoring a series of co-operative summer sessions in statistics.

The first of these co-operative graduate summer sessions was held during the summer of 1954 at Virginia Polytechnic Institute. The second session will be held at the University of Florida from June 20 to July 29, 1955. A session is scheduled to be held at North Carolina State College in 1956, and another at Virginia Polytechnic Institute in 1957.

The summer sessions are designed to carry out a recommendation of the Southern Regional Education Board's Advisory Commission on Statistics, on which the three institutions initiating the program are represented. The sessions will be of particular interest to: research and professional workers who want intensive instruction in basic statistical concepts and who wish to learn modern statistical methodology; teachers of elementary statistical courses who want some formal training in modern statistics; prospective candidates for graduate degrees in statistics; graduate students in other fields who desire supporting work in statistics; and professional statisticians who wish to keep informed of advanced specialized theory and methods.

Each of the summer sessions will last 6 weeks and each course will carry approximately three semester hours of graduate credit. The program may be entered at any session, and consecutive courses will follow in successive summers.

Courses to be offered this summer are: Statistical Methods I, Statistical Methods II (Design of Experiments), Statistical Theory I, Statistical Theory II (Inference and Least Squares), Advanced Analysis I, Theory of Sampling, Theory of Statistical Inference, Mathematics for Statistics, Statistical Research in Education, and Psychology and Seminar on Recent Advances in Statistics.

The University is in Gainesville, located in north central Florida, midway between the cooling breezes of the Gulf of Mexico and the Atlantic Ocean. Inquiries should be addressed to: Professor Herbert A. Meyer, Statistical Laboratory, University of Florida, Gainesville, Florida.

New Method for Rate-Measurement of Watthour Is Used

A more rapid method for precisely measuring the rate of a-c watt-hour meters has been developed by T. L. Zapf and A. W. Spinks of the National Bureau of Standards (NBS). This method reduces to a minimum the use of an electrodynamic wattmeter and the laborious process of holding the a-c power constant while the meter registration is accumulating. In lieu of regular use of the wattmeter for all tests, measurements may now be made by a comparison process that employs a group of carefully selected a-c watt-hour meters, one of which has been adapted for use as a "standard watt-hour meter" while the others serve as comparison standards. Specifically the rate comparisons are performed by comparing the number of revolutions of the disk of the watt-hour meter under study with that of the standard meter. The standard meter must initially have had its rate determined by the older method.

Standard watt-hour meter setup at the National Bureau of Standards. In the foreground are (left to right) the "standard watt-hour meter" in its circular housing; the pulse counter and electronic timing and counting circuits which determine accurately the duration of a test run; and the a-c power supply which energizes the coils of the standard or the watt-hour meter under test

Close-up of the standard watt-hour meter assembly used by the National Bureau of Standards for the rate-comparison watt-hour meters. The standard watt-hour meter with its rotating mirror is in the center of the large cylinder. Above the mirror is the mercury-vapor lamp and lens housing. The phosphorescent scale (white) and the engraved plastic reading scale (below) are mounted near the edge of the large cylinder

A watt-hour meter is essentially an integrating wattmeter in that the time rate of angular rotation of its disk is proportional to the power supplied to the load. Thus, the number of turns of the disk during a certain time interval is proportional to the electric energy delivered through the watt-hour meter to the load. In high-precision NBS tests in the past, this has ordinarily been done by observing the number of disk revolutions occurring in a fixed time interval during which the power has been held constant. The power was indicated by the deflection of an electrodynamic wattmeter previously calibrated on reversed direct current. This fundamental procedure was capable of high accuracy but was necessarily tedious and difficult.

It has been known for many years that certain individual watt-hour meters may exhibit remarkable stability over long periods of time. Thus, in an effort to develop a more rapid testing procedure, it was decided to carefully select several watt-hour meters and to use them as a standard group for testing other watt-hour meters by a comparison of their rates.

The meter selected as a standard is a modified portable commercial watt-hour meter (rotating standard). This unit has been provided with a shaft extension, and its register has been removed. The meter is mounted in a temperature-controlled box. A light-beam pointer has been provided by mounting a mirror inclined at 45° on the upper end of the shaft. A beam of light incident vertically on the mirror is deflected horizontally to an encircling scale provided with a phosphorescent band. A phototube is placed behind a vertical slit in the phosphorescent band so that the light beam strikes the phototube once each revolution. The amplified pulse from the phototube energizes an electromagnetically-operated mechanical counter for counting the number of complete revolutions of the disk of the standard watt-hour meter during a run.

A mercury-vapor lamp placed above a small circular aperture serves as the light-pointer source. A lens focuses the image of the aperture on the phosphorescent band. Any current pulse through the lamp will cause a momentary intensification of the light which results in a luminous spot being left on the phosphorescent band. This spot will persist for several seconds; long enough for an operator to note its position on the engraved plastic scale.

The duration of a test run, in one method of operation, is determined by a photoelectrically operated controller that counts a preset number of complete disk revolutions of the watthour meter under test. This method can be employed if the meter under test is of a type readily adapted to photoelectric pickoffs. Precisely at the beginning and end of each run the amplified output from the phototube associated with the watt-hour meter under test triggers an electronic circuit that pulses the mercury-vapor lamp and produces a persistent spot of light on the phosphorescent band. The positions of these two spots can be read to the nearest thousandth of a revolution on the adjacent scale. Any fractional part of a revolution of the standard watt-hour meter can be computed from these two readings. Thus, the number of revolutions of the disk of the standard equals the reading of the mechanical counter plus the scale reading at the end of the run minus the scale reading at the beginning of the run.

New Dam and Reservoir Built in Puerto Rico

Dedication of the Antonio Luchetti Dam and Yauco Reservoir was announced by Carl A. Bock, executive director of the Puerto Rico Water Resources Authority. This is the second of five major dams being built in connection with the southwestern Puerto Rico project. This project extends over an area of 250 square miles and encompasses the reclamation and utilization of 26,000 acres of land; development of 100-million kilowatt-hours annually of hydroelectric energy; development of a potable water supply for communities in the southwestern part of the island, and protection from floods in several river basins.

Part of the project involves diversion of water through the mountain divide of nearly 8 miles of tunnels. Construction of two of the three remaining major dams is well under way, and work on the foundations for the fifth dam has begun. The source of water and power features will cost the Authority over 25-million dollars, and the irrigation feature financed by the Commonwealth of Puerto Rico will cost almost 7-million dollars.

Antonio Luchetti Dam and Yauco Reservoir in Puerto Rico

College Recruiting Trends Show Many Opportunities for Graduates

According to the Engineering Manpower Commission of Engineers Joint Council and the Scientific Manpower Commission in the *Newsletter*, the 1955 Midwest College Placement Association's "College Recruiting Survey" shows that opportunities for 1955 graduates are very promising. The following two questions from the survey and the answers are illuminating:

How will your 1955 requirements for college-level men compare with those for preceding years?

	1955 versus 1954 No. of Companies		1954 versus 1953 No. of Companies	
	Tech.	Non-Tech.	Tech.	Non-Tech.
More	32	17	32	15
The same	102	101	69	68
Less	26	30	32	18
	160	148	133	101

As nearly as you can now estimate, what will your 1955 gross monthly salary offering be for men without previous business or industrial experience?

	1955—Non-Veteran No. of Companies					
	Technical			Non-Technical		
Salary Range	Bach.	Master	Ph.D.	Bach.	Master	
$250 or under	1			5	1	
251–275	1			3		
276–300	7			24	4	
301–325	13	2		44	11	
326–350	43	12	3	41	22	
351–375	67	19	1	22	18	
376–400	26	34	2	4	20	
401–425		39	3		8	
426–450	1	9	7			
451–475			1			
476–500			7			
501–525			11			
526–550			21			
551–575			12			
576–600			4			
601–625			1			
	159	115	73	143	85	

Engineers Prune Verbiage in Letter-Writing Course

United States' businessmen, portrayed the world over as aggressive, fast-talking executives, become amazingly inarticulate when pressed to dictate or write letters. Their self-assurance melts and they take refuge in cautious, wordy, and involved writing.

One firm, Minneapolis-Honeywell's Brown Instruments Division, Philadelphia, Pa., in the spirit of self-analysis, recently organized a class of verbiage pruners among its letter writers.

Since this division sends out some

3,000 letters daily, besides composing and circulating approximately 5,000 interoffice memos, C. L. Scheetz, training director, estimated that inefficient dictating could be costing the firm hundreds of thousands of dollars yearly.

Contributing to that inefficiency is the tendency to "write like a man walking on stilts," Scheetz said. "Many of us, unless trained to say things as plainly on paper as we do in talking, often "pace off" a 50-word sentence without realizing it."

The firm's students are learning to organize their thoughts before dictating. Then they are urged to talk clearly (without chewing on a pipe or cigar) using simple, clear words and short sentences (21 to 30 words). The ultimate aim? Letters which will be opened, read, understood, believed, agreed with, and acted upon.

Million-Kw Generating Plant to Be Built Along Ohio River

Ohio Power Company recently announced that it is acquiring approximately 650 acres of land along the Ohio River near Ironton, Ohio, as the site of a future 1-million-kw steam-electric generating plant.

Philip Sporn, president of Ohio Power and its parent company, the American Gas and Electric Company(AGE), said that construction of the new plant would be undertaken when the demand for electric service called for the additional expansion of its facilities. He pointed out that the Ironton site was chosen for two principal reasons: its proximity to coal reserves and its location close to the center of the AGE System's seven-state service territory.

Scholarships Given by The Ohio Brass Company

The Ohio Brass Foundation, a nonprofit organization established by The Ohio Brass Company, Mansfield, Ohio, awards scholarships to students from its plant areas who plan to seek degrees in certain technical sciences. Awards are based on scholastic standing, leadership qualities, personality, and other factors. The Foundation will pay all tuition and academic fees and part of room and board expenses for 4 or 5 years depending on the length of the courses.

High-Intensity Projection Lamp Developed by Navy Engineers

A 2,000-lumen projection lamp which produces more than 3 times the illumination previously available for 16-mm motion picture projectors has been developed by engineers of the Bureau of Ships, the Navy announced recently.

The high-intensity lamp, designed for the JAN (Joint Army-Navy) 16-mm projector, will be used by the Navy aboard large ships where wide screens require strong illumination and in outdoor theaters on Navy bases overseas. The new lamp also has commercial applications, including use in the fields of television and photography, as well as in commercial movie projectors. It is considered to be highly suitable for color and black-and-white film.

The incandescent light source previously available for the JAN 16-mm projector produced only 525 lumens. In view of the superior performance of this projector, the Navy desired a stronger lamp that would fit into the projector without major equipment redesign.

In addition to its 2,000-lumen output, the new projection lamp has uniformity of screen illumination; average illumination at four corners is 77 per-cent of illumination at center of the screen, and low corner illumination is 75 per cent of the illumination at the screen center.

Navy Icebreaker Embarks for Antarctic Scientific Expedition

The USS Atka, United States Navy icebreaker, embarked from Boston recently on a 5-month's expedition to the Antarctic. The expedition, under the command of Commander Glen Jacobsen, will spend almost 2 months within Antarctic waters engaged in studies preliminary to the International Geophysical Year (IGY), 1957–58, when 38 nations will carry out a world-wide research effort embracing such fields as meteorology, cosmic rays, solar activity, ionospheric physics, geomagnetism, oceanography, and glaciology. The United States program of the IGY is to be carried out under the joint auspices of the National Academy of Sciences and the National Science Foundation.

An interesting study of the phenomena of "whistling atmospherics" at audio frequencies will also be conducted. Whistlers are electric noise disturbances originating in lightning flashes. The experiment is to test the theory of the propagation of these whistlers. It is supposed that they propagate far outside the ionsphere, and that they return to the earth in the opposite hemisphere. There, they seem to be reflected, and return along the same path to the place of origin, where an echo "whistler" is observed. The question raised by scientists is: are whistlers observed at both conjugate points in the Northern and Southern Hemispheres at the same time? This requires simultaneous observations at appropriate places in the two hemispheres. Accordingly observations are planned during the voyage at points in the Southern Hemisphere conjugate to the several existing observation points in the Northern Hemisphere.

These whistlers, which are expected at a rate of at least one every 2 hours, will be recorded on magnetic tape. The time of occurrence of the whistlers must be determined to within a second, as also the dispersion of frequency. The timing is extremely important, and systematic monitoring of various standard-frequency stations will aid in keeping accurate checks on the chronometers to be used, as well as helping to determine the range and effectiveness of the standard frequency signals.

New Engineering Laboratory to Be Built in Boston Area

An engineering laboratory for the development of specialized electronic fire-control systems for military aircraft will be established by the Radio Corporation of America (RCA) in the greater Boston area early next year, it was announced by Theodore A. Smith, vice-president and general manager, RCA Engineering Products Division. By the end of 1955, it will provide employment for approximately 100 scientists, engineers, and laboratory personnel.

Dr. Robert C. Seamans, Jr., nationally known authority on airborne electronics, has been appointed manager of the new laboratory. Dr. Seamans, who received his doctorate in instrumentation from the Massachusetts Institute of Technology in 1951, has been associate professor at MIT since 1949, and for the past 2 years served also as director of the MIT flight control laboratory.

Location of the new RCA development activity in the Boston area reflects the growing importance of New England as a center for the engineering and development of electronic systems for a wide range of military and industrial applications.

Winners of the first two Ohio Brass Foundation scholarships recently visited the Ohio Brass factory in Mansfield. Looking over some malleable iron strain clamps are R. B. Black, president of the Foundation, F. E. Bair, factory manager, David L. Powell, and Russell M. Stender, winners

Fourteen Generators Installed at McNary Dam on Columbia River

In a news item about the hydraulic turbine-driven generators at the McNary Dam (*E.E., November 1954, p. 979*), the number of units mentioned was 12, being manufactured by one company. The power house is constructed to accommodate 14 generators. Two of the total number are being manufactured by The English Electric Company, Ltd., of Stafford, England.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

PROCEEDINGS OF THE SYMPOSIUM ON OPERATIONS RESEARCH IN BUSINESS AND INDUSTRY. Sponsored by Midwest Research Institute, Kansas City, Mo., 1954. 185 pages, 11 × 8½ inches, paper. $5. Eleven papers, the first on the nature of operations research and its background, the remainder mainly on applications to management problems—office procedures, marketing, traffic and transportation, etc. One of the papers discusses scheduling batched operations in petroleum products pipe lines.

PROFITING FROM INDUSTRIAL STANDARDIZATION. By Benjamin Melnitsky. Conover-Mast Publications, Inc., 205 East 42nd Street, New York, N. Y., 1953. 381 pages, 9¼ × 6¼ inches, bound. $5.50. This book, of interest mainly to management engineers and executives, shows how to develop, distribute, and use industrial standards. Based largely on current American practice and illustrated by case histories, the book covers sources of industry, national, and government standards; organizing a standards department; developing and applying company standards; classification; part numbering; design and purchasing standards; and related subjects.

QUANTUM MECHANICS. By F. Mandl. Academic Press Inc., 125 East 23rd Street, New York 10, N. Y., 1954. 233 pages, 10 × 6½ inches, bound $5.80. Written as an introduction to the subject, this work presupposes a knowledge of classical physics, calculus, vector analysis, and the qualitative concepts of quantum theory, such as the wave nature of matter. The first five chapters cover underlying mathematical methods, wave-mechanical concepts, examples of energy eigenfunctions, general principles of quantum mechanics, and matrix mechanics. The last four chapters illustrate the use of the theory in solving specific problems involved in systems of many particles, perturbation theory, scattering, and group theory.

RURAL ELECTRIFICATION, 2 VOLUMES. United Nations Economic and Social Council (available in U. S. from Columbia University Press, 2960 Broadway, New York 27, N. Y.) 1954. 163 pages, 165 pages, 11 × 8½ inches, paper. $1.50, $1.25. These volumes, containing summaries of reports from 14 European countries, have been published in order to make the information available to less industrialized areas. Volume I briefly surveys resources for power production, discusses technical aspects of transmission and distribution, and reviews economic, financial, and administrative problems. Volume II contains reports on the use of electric power in agriculture and for various purposes in rural areas.

SMITHSONIAN PHYSICAL TABLES. (Smithsonian Miscellaneous Collections, vol. 120) Prepared by William Elmer Forsythe. Smithsonian Institution, Washington, D. C., ninth edition, 1954. 827 pages, 9½ × 6½ inches, paper. $9. Data of interest to engineers, physicists, and other scientists is tabulated in this book from the best available sources. Tables are arranged in groups of related data under such representative designations as general physical constants, physical and mechanical properties of materials, characteristics of dielectrics, general conversion factors, etc. In this edition there are some 30 more tables than in the preceding issue of 1934, material has been rearranged for ease of use, and the index has been enlarged. Some older references have been omitted.

SYMPOSIUM ON TEMPERATURE STABILITY OF ELECTRICAL INSULATING MATERIALS. (Special Technical Publication, no. 161). American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1954. 136 pages, 9 × 6 inches, paper. $2.75. Eleven papers with discussion are included. Among the topics covered are the following: measurement of dielectric properties at high temperatures; effects of high temperatures on electrical properties of thermosetting plastics, on resistivity of bonded micaceous materials, and on silicone varnished glass fabric insulation; and the thermal stability of insulating fabrics, polyvinyl chloride compounds, insulating varnishes, and sheet insulation.

STEAM, AIR, AND GAS POWER. By William H. Severns, Howard E. Degler, John C. Miles. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., fifth edition, 1954. 502 pages, 8½ × 5¾ inches, bound. $6.50. Basic information on heat-power theory, equipment, and practice for a first course in the subject is provided in this standard text. In revising the book the authors have reduced material on steam engines to one chapter and have modernized treatment of auxiliaries and equipment. There is a new chapter on refrigeration, and new material on centrifugal and axial-flow fans, oils and gases, and gas turbines.

SYMPOSIUM ON FATIGUE, SYMPOSIUM ON HUMAN FACTORS IN EQUIPMENT DESIGN. (Ergonomics Research Society Proceedings, Volumes I and II) Edited by W. F. Floyd and A. T. Welford. H. K. Lewis and Company, Ltd., London, England, (distributed in U. S. by John de Graff, Inc., 64 West 23rd Street, New York 10, N. Y.) 1953, 1954. 196 pages, 132 pages, 9½ × 6½ inches, bound. $4. each. The papers in these symposiums present the viewpoints of anatomists, physiologists, psychologists, and industrial engineers. Papers in the first consider temperature, lighting, and other factors producing human fatigue, and record results of studies of its effects. Typical subjects discussed in the second are range and strength of joint movement, response to variously designed visual indicators, and equipment layout.

TELEVISION AND SPECIAL TUBES VADE MECUM, 1954. P. H. Brans', Ltd., Antwerp, eleventh edition, 1954. 244 pages, 11⅛ × 8 inches, paper. $5. Data on tubes of manufacturers of many countries are presented in tables classified by major divisions—cathode ray tubes, crystal devices, controlled rectifiers, etc. This edition completes coverage of an extensive range of tubes begun with the ninth edition (radio tubes), and continued in the tenth edition (equivalent radio tubes).

THE PHYSICS OF EXPERIMENTAL METHOD. By H. J. J. Braddick. John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 404 pages, 8¾ by 5½ inches, bound. $7.00. Attention is directed to the branches of physics which are important in planning and executing experiments in physical research, with emphasis on principles and presently available techniques. Material is included on errors and the treatment of experimental results, on the design of apparatus from the mechanical standpoint, on materials used in apparatus design, and on instruments and their uses in a wide variety of fields.

HUMAN ENGINEERING GUIDE FOR EQUIPMENT DESIGNERS. By Wesley E. Woodson. University of California Press, Berkeley 4, Calif., 1954. Various paging, 10⅛ × 8 inches, paper. $3.50. Provides practical, detailed recommendations for designing equipment (visual and aural indicators, controls, furniture, panels, etc.) and for designing working areas, taking into account lighting, temperature, ventilation, effects of noise and vibration, and other problems. Vision, hearing, body dimensions, and other human factors are separately treated in relation to equipment design. There are chapter references and a classified bibliography.

MAGNETIC VARIOMETERS OF THE SCHMIDT TYPE. By J. McG. Bruckshaw. Hilger & Watts Ltd., Hilger Division, London, England, 1954. 115 pages, 8¾ × 5¾ inches, bound. 22s. Describes the construction, maintenance, and use of the instruments of Hilger & Watts, Ltd. as an aid to adjustments and repairs by operators in the field. The magnetic method of geophysical prospecting is discussed briefly.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

PAMPHLETS

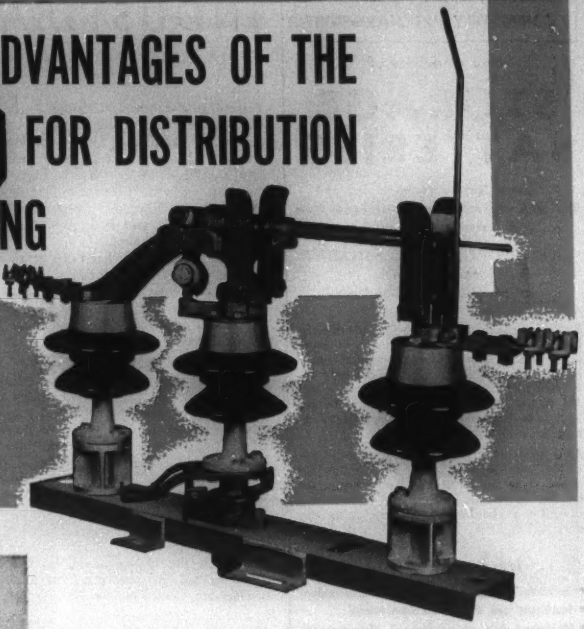
The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

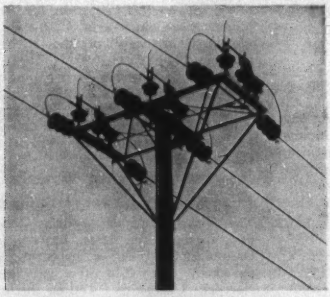
A Commutating Device for Transforming Shaft Position into Binary Digit Information. No. of Report, PB 111340. A "line contact" method of preventing bounce and establishing clean and reliable contact between brushes and tracks is featured in this design of a 9-digit commutating device. Contact bounce is avoided by having the brush spring and contact formed from a single piece of precious-metal wire. Area of the sliding contact is kept small and the total brush pressure low. Photographs of the assembled commutator and disassembled components are included. 9 pages. $1.00. Available from Office of Technical Services, U. S. Department of Commercie (Commerce Building, Room 6227), Washington 25, D. C.

Electrets. Better understanding of the electrical properties of carnauba wax electrets may lead to important applications of the material as the sensitive element in such electronic equipment as microphones and loud-speakers, and as "memory" devices in large-scale computing machinery. Basic research into dielectric properties is described in this report. Of primary interest is the ability of electrets to reverse their original charges and maintain the high final charge for several years. Discharge currents for electrets of varying thicknesses, construction and original charge are given in graphs and tables. Experimental techniques are discussed and illustrated, including the preparation of wax samples. 116 pages. Microfilm $4.75. Photostat $15.00. The report is available from the Library of Congress, Publication Board Project, Washington 25, D. C. Code number of report is PB 112749.

15 Home Lighting Ideas. The illuminating Engineering Society has published a packet of home-lighting data sheets titled "15 Home Lighting Ideas" for the use of anyone interested in lighting and decoration for residential interiors and of particular value to residence architects, interior decorators, and utility-company home-lighting specialists. These data sheets show the latest lighting techniques for a wide variety of home areas, complete with construction and installation details. The sheets include photographs to show just how the completed job looks; line drawings and sketches with accurate measurements for custom-built installations; and complete illumination data for those who want the best in lighting results. In keeping with modern home design, titles of the sheets include Lighting a Window-Wall; Lighting for a Built-In Sofa; Lighting a Lavatory and Powder Counter; A Remodeled Kitchen with Soffit Lighting; and Lighting for a Laundry. Based upon the standards of the Illuminating Engineering Society, the home lighting idea packet is the work of the Society's Subcommittee on Residence Lighting Data Sheets. Single copies of the packet, $1.00. Write to Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

CHECK THE ADVANTAGES OF THE TYPE WAG FOR DISTRIBUTION LINE SWITCHING





OKLAHOMA—This photo shows Type WAG switches on standard switch frame, pole-top mounted.

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with standard controls are now available *in stock* for pole-top mounting of Type WAG in conventional manner. For further information on this inexpensive method of mounting, write direct to factory or ask your Southern States representative. The WAG is also designed for mounting on wood cross arms.

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INDUSTRIAL NOTES ....

Fairchild Personnel Changes. Frank G. Mullins, Jr., has joined the Fairchild Recording Equipment Company, Whitestone, N. Y., as manager of engineering and special counsel. Mr. Mullins was formerly with the Electronic Division of Westinghouse Electric Corporation in Baltimore, Md., and is a graduate of the University of Alabama.

Robert J. Marshall has been promoted from chief engineer to head the recently established New Product Development group. He will be responsible for analyzing new products under consideration for manufacture and sales.

Honeywell Buys Boston Firm. Minneapolis-Honeywell Regulator Company has purchased all of the outstanding capital stock of Doelcam Corporation of Boston, Mass., manufacturer of precision instrument and control equipment for aircraft and industry uses. The firm, which has a main plant and administrative offices in Boston and engineering laboratories in Newton, Mass., will be operated as a new division of Honeywell. There will be no change in the management, headed by John J. Wilson, president and founder of Doelcam.

New Federal Pacific Plant. Federal Pacific Electric Company, Newark, N. J., has opened a new plant in Scranton, Pa., as headquarters for the company's newly organized Eastern Switchgear Division. In addition to manufacture of low-voltage high-capacity switchgear and high-voltage switchgear, activities at the plant also include the manufacture of structures and other assorted equipment. The Eastern Switchgear Division is under the over-all supervision of E. A. Williams, recently appointed manager.

Burndy's New York Offices Move. Burndy Engineering Company, Inc., electric connector manufacturers of Norwalk, Conn., announce the relocation of the New York sales office from the Bronx to 20 East First Street, Mount Vernon, to serve better the district's territory in New York City, Long Island, northern New Jersey, and up through the Glens Falls section of New York State. The new office is under the supervision of L. S. Berkley, manager, New York sales.

Daystrom Expansion. Purchase of the assets of the American Gyro Corporation, Santa Monica, Calif., manufacturers of gyroscopes and miniaturized control equipment for guided missiles and aircraft, has been announced by Daystrom, Inc., of Elizabeth, N. J. Daystrom will conduct the company as a wholly owned subsidiary to be known as Daystrom Gyro Corporation, and the gyroscope portion of the business will be run under the name of the American Gyro Division. The company will be operated under its present management, with John W. Bamford continuing as president, and Robert B. Kees and Robert Bowditch as vice-presidents. Fred H. Schaberg, formerly chief accountant of Daystrom Instrument Division, has been named treasurer and assistant secretary.

Cook Electric Appoints Burton. Cook Electric Company, Chicago, Ill., announces the appointment of Charles Burton as manager of the Eastern Sales Division with offices in New York, N. Y. Mr. Burton was formerly assistant to the president of Federal Enterprises, Inc., Chicago. He is also consultant to the Federal Civil Defense Administration on air raid warning systems in prime target areas in the United States as well as at air stations, naval bases, and similar installations.

Allis-Chalmers Announcements. Charles L. Crosby, manager of the Richmond district office of the Allis-Chalmers General Machinery Division, died December 8, 1954. An electrical engineering graduate of the University of Wisconsin, Mr. Crosby joined Allis-Chalmers in 1923. He was appointed manager of the Richmond office in 1940.

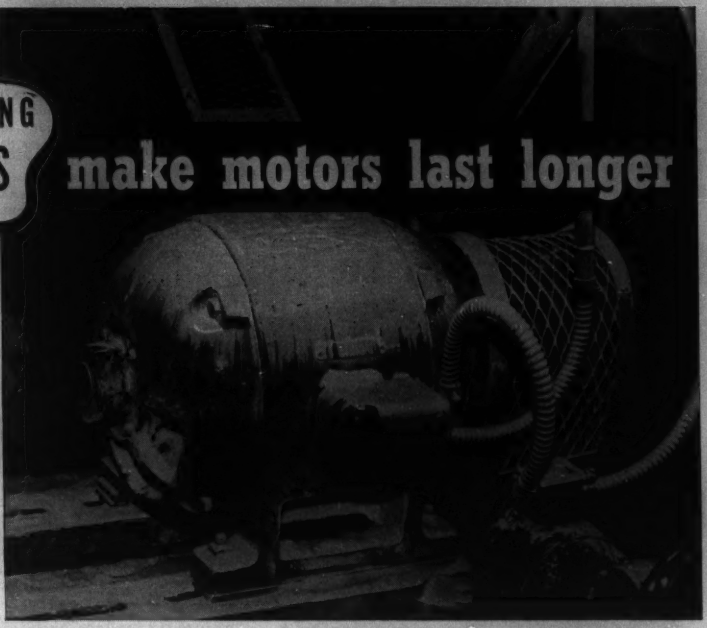
Donald B. Scott has been named engineer-in-charge of sales for the company's induction heating group. He joined Allis-Chalmers in 1937 after receiving his electrical engineering degree from Purdue University.

Vice-President for Nickel Cadmium. The Nickel Cadmium Battery Corporation, Easthampton, Mass., has appointed Grenville B. Ellis as executive vice-president. Mr. Ellis is a graduate of Norwich University. During his early business career he was with the Westinghouse Electric Corporation as electronics engineer, and from 1935 to 1940 was chief engineer of Control Instrument Company, Inc. (now owned by Burroughs Corporation). Since 1940 he has been chief of the Power Sources Branch, United States Signal Corps.

NBS Appoints Dr. Lyons. Dr. Harold Lyons, formerly chief of the Microwave Standards Laboratory, has been named assistant chief for research of the Radio Standards Division of the National Bureau of Standards' Laboratories at Boulder, Colo. He will direct research phases of the standards program, including development of improved transfer standards, methods of measurement, instruments and instrumentation techniques. Dr. Lyons received his bachelor's degree from the University of Buffalo and his master's and doctorate from the University of Michigan. He joined the staff of the Naval Research Laboratory in 1939 and came to the National Bureau of Standards in 1941.

(*Continued on page 28A*)

DOW CORNING
SILICONES
make motors last longer



one class H motor saves $44,000 in downtime costs

10 hp Class H conveyor motor lasts over 36 times as long as 25 hp Class A; savings to date in downtime costs, $44,000.

A screw conveyor carrying dry stucco mix in the Kaiser Gypsum Company plant at Long Beach, California, was originally driven by a 25 hp Class A insulated motor. Damp material accidentally placed in the conveyor overloaded the motor causing burn-outs and work stoppages. With production shutdowns costing about $700 an hour, every effort was made to prevent over-loading, but the motor still failed every 30 to 60 days.

In December 1948, the Class A motor was replaced with a 10 hp Silicone (Class H) insulated unit. Although the silicone insulated motor has less than 50% of the name plate rating of the Class A motor, it is still operating after 6 years of service without a single failure. At a conservative estimate, the saving in downtime costs alone is over $44,000.

That's typical of the performance of silicone insulated electrical equipment under tough operating conditions in every industry; over-load capacity increased by as much as 50%; service life increased at least 10 times; production and maintenance costs reduced to permit a better profit margin. Top management, production and maintenance engineers are demanding more and more Class H insulated motors, transformers and solenoids, because they cost less in the long run.

You can also reduce to a minimum motor outages due to bearing failure by using Dow Corning 44 Grease

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(*Continued from page 18A*)

New Westinghouse Department. The Westinghouse Electric Corporation, East Pittsburgh, Pa., has announced the formation of a new products engineering department to be headed by Dr. W. H. Brandt, formerly manager of special products development. Work of the new department will be closely co-ordinated with that of the company's research laboratories and the materials engineering department.

Hubbard Expansion Program. Hubbard and Company, manufacturers of pole line hardware, has completed a $1,500,000 expansion and modernization program at its three major plants—in Oakland, Calif., Chicago, Ill., and Pittsburgh, Pa. The Pacific branch has added 40,000 square feet of floor space including a new building for galvanizing operations and additional room for storage of raw materials and assembly operations. Chicago operations, in nearby Cicero, have been expanded through addition of a new warehouse and loading dock, while space formerly used for warehousing is being utilized for an improved research and engineering laboratory. In Pittsburgh, the program includes warehousing and shipping improvements, layout and equipment changes in pole line hardware manufacturing operations, machine shop modernization in the tool division, and installation of new finishing and materials handling equipment in the aluminum products plant.

General Electric Notes. The General Electric Company will establish a new electron tube development laboratory to be located near Stanford University in the industrial and technical center being developed by the university within the city limits of Palo Alto, Calif. Work at the laboratory will be concentrated on developing and exploring the application of microwave electron tubes. Personnel will work closely with Stanford's Electronics Research and Microwave Laboratories. Manager of the new laboratory will be H. R. Oldfield, Jr., former manager of the General Electric Advanced Electronics Center at Cornell University.

Plans to center complete engineering, as well as manufacturing, of the company's germanium rectifiers and diodes at the Clyde, N. Y., plant have been announced. Raymond A. York has been named as manager of germanium diode and rectifier engineering.

General Electric has also announced a company-wide purchasing training course as a step toward manpower development to meet the anticipated growth in the electrical industry. James A. McAleer, manager of purchasing research services, will co-ordinate the program with Douglas V. Smith as specialist in charge of purchasing training.

In the Carboloy department of General Electric at Detroit, Mich., Robert A. Canning, former manager of production engineering, has been named manager of quality control. He is a graduate of the Massachusetts Institute of Technology.

(*Continued on page 34A*)

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Far outlasts *any* other cord made!

Service to cost ratings show new U. S. Royal Master Cord actually gives $1.88 in value for every cord dollar when compared to the average competitive molded cord!

Two years ago, "U. S." engineers began a *complete reexamination* of portable cord construction, service life, and the causes of cord failure.

Over 10,000 tests were made. More than a thousand cords of all leading makes, including our own famous U. S. Royal Cord, were analyzed, tested, and compared.

Every life factor was considered and carefully evaluated, alone and in its relation to overall cord performance and service life.

Backed by 64 years of experience in the manufacture of electrical wire and cable, U. S. Rubber engineers then translated their findings into an entirely new portable cord, designed to surpass any other previously made.

Extensive tests, both in the laboratory and in outside plant installations have proved this new portable cord startlingly superior in every respect!

New U. S. Royal Master is unquestionably the finest cord you can buy!

From every standpoint, new U. S. Royal Master is a finer, more durable cord — actually gives 88% longer life than the average of other molded cords — far longer than *any* other cord — surpassing even a *hypothetical* cord incorporating the best features of all those tested!

Far greater value, too! In spite of almost doubled service life, this great new cord is in the same price category as other molded cords—giving you $1.88 in cord value for every cord $1.00!

Prove to yourself the outstanding superiority of new U. S. Royal Master Portable Cord—in both service life *and* economy! Write address below for FREE descriptive booklet illustrating the superiority of the U. S. Royal Master Cord. And get in touch with your "U. S." distributor today!

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Stoddart RI-FI* Meters cover the frequency range 14kc to 1000mc

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NM-10A, 14kc to 250kc. Commercial Equivalent of AN/URM-68. Very low frequencies.

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(Continued from page 28A)

Two engineers have been added to the newly formed vacuum-melted alloys section of the department. They are Donald K. Miner, formerly a jet-engine materials engineer with the company's Evendale, Ohio, Aircraft Gas Turbine Division, and J. David Benedict, who transferred from the department's permanent magnetic operations.

Allen-Bradley Assignments. D. S. W. Kelly, electronic component engineer for Allen-Bradley Company, Milwaukee, Wis., is now in charge of preparation of the company's electronic data and publications under the direction of William W. Garstang, chief engineer of the Radio Division. George Vater, looking after radio sales at headquarters, will be assisted by Lanier Gray, who for many years was connected with the Signal Corps in Washington, D. C.

Martin Enters Nuclear Field. Martin Aircraft, Baltimore, Md., has established a separate Nuclear Division for the development of nuclear reactors and related components for military, industrial, and commercial use. Tibor F. Nagey, formerly with the National Advisory Committee for Aeronautics (NACA), is manager of the new division. Dr. Robert Spooner, former head of the thermodynamic analysis section at the NACA Lewis Flight Propulsion Laboratory, has been named manager of nuclear research and development. James Dunlop, recently Martin manufacturing manager of electronics products, has been named manager of nuclear manufacturing. William A. Maxwell, metallurgist, heads nuclear production engineering. Howard F. Dunlap, Martin Army sales representative, has been appointed manager of nuclear products development. Russell L. Hopping, who served as design engineer for guided missile warheads, is in charge of marketing research.

New Leeds and Northrup Plant. Leeds and Northrup Company, Philadelphia, Pa., has awarded the first portion of the general contract for construction of its new plant, adjoining North Wales, Pa., to Baton Construction Company, Philadelphia. The plant will produce the various types and models of Speedomax controllers, recorders, and indicators, together with panels and cubicles for certain applications, and possible other products.

IBM Assignments. International Business Machines Corporation has announced the appointments of John H. Matthews as manager of programs and schedules, William M. Hoyt, Jr., as manager of personnel for engineering, and Douglas G. Knight as manager of methods and services. All three posts are in the office of the director of laboratory operations at the company's headquarters in New York, N. Y. Mr. Matthews was formerly assistant to the IBM laboratory adminis-

(Continued on page 36A)

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RCA Announces the FIRST Low-Cost

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PROVED throughout the nation and the world, RCA 960 megacycle Microwave is now available in a low-cost "package" unit, MM-9, as a complete station.

Important savings include:

- **Minimum real estate requirements**
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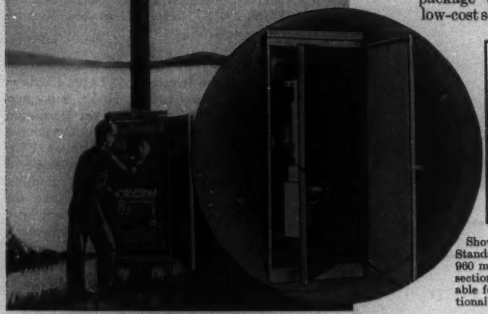
When mounted on inexpensive supports, such as wooden poles, up to 100 feet high, or on existing structures, which can be spaced 20 or more miles apart, the MM-9 Microwave "package" units provide an ideal low-cost solution to many point-to-point communications problems.

RCA Microwave uses highly directional radio signals which are beamed from one relay station to the next by "dish" antennas. It can be interconnected with existing telephone lines and switchboards and virtually eliminates the weather hazards of carrier and wire lines. RCA Microwave employs readily available tubes and familiar circuits which are easy to service. The RCA Service Company provides nationwide installation and service facilities, if desired.

For complete information on the new MM-9 Packaged Microwave Stations, send coupon, below.



Showing hinged rack construction, with all components easily accessible for servicing. Standard "package" equipment includes weather-proof cabinet, 2 parabolic reflectors, 960 megacycle transmitter unit, exciter unit, 960 megacycle receiver. Also 2 100-ft. sections of semi-flexible transmission lines with all required fittings. Space is available for multiplex equipment to provide two voice channels with signaling. Additional multiplex equipment can be mounted in a similar cabinet.

Typical Uses of MM-9 Packaged Microwave:

1. Telephone Circuits
2. Supervisory Control
3. Remote VHF Control
4. Facsimile
5. Teletype

FOR

- Gas Utilities
- Electric Utilities
- Pipelines
- State Agencies
- Municipal Systems
- Police Departments
- Transportation Systems

RCA

RADIO CORPORATION of AMERICA

COMMUNICATIONS EQUIPMENT
CAMDEN, N. J.

Radio Corporation of America, Camden, N. J.
Dept. N-42, Building 15-1
In Canada, RCA VICTOR Company Limited, Montreal
Please send me your new booklet, "RCA Low-Cost Packaged Microwave Stations."

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

☐ *Have an RCA representative get in touch with me.*

ELECTRONS, INCORPORATED
127 SUSSEX AVENUE
NEWARK 3, N. J.
Electrons' preferred modern gas-filled thyratrons are the first choice of leading electronic equipment designers.

(*Continued from page 34A*)

trator at Endicott, N. Y., Mr. Hoyt was administrator of engineering recruitment, and Mr. Knight was formerly head of the management procedures group in the office of the laboratory administrator at Poughkeepsie, N. Y. Also announced was the promotion of James H. Potter to development engineer at the company's Endicott Engineering Laboratory.

NEW PRODUCTS • •

Silicone Varnish. A modified silicone dipping and impregnating varnish has been developed by Dow Corning Corporation, Midland, Mich., which substantially increases the durability of electric equipment insulated with class *B* components. Identified as Sylkyd *1400* Varnish, it combines good heat stability with excellent bond strength and outstanding resistance to mositure, oil, and solvents, and is particularly adaptable to railroad traction motors and other heavy-duty equipment which carry frequent overloads and must be cleaned periodically for inspection and performance checking. Samples and further information are available on request to the company.

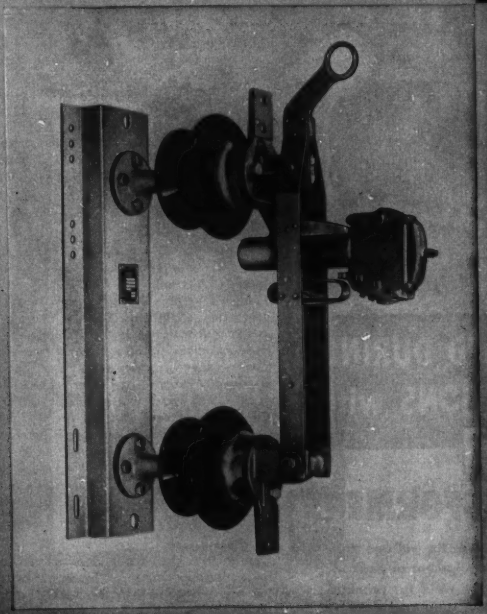
Small Compact Solenoid. A recently developed small and compact solenoid is now available in quantity for small equipment and components. The new solenoid, which is especially adapted to rugged duty, will operate in any position and is regularly furnished for both constant and intermittent duty, 115-volt 60-cycle alternating current. Blade terminals are standard, with flexible leads optional. For further information, contact Dormeyer Industries, Department EGN, 3418 North Milwaukee Avenue, Chicago 41, Ill.

Station Post Insulators. Lapp Insulator Company, Inc., LeRoy, N. Y., announces three new 161-kv Station Post Insulators, standard strength, with 1,200 pounds cantilever rating, high strength at 1,700 pounds, and extrahigh strength rated at 3,500 pounds. These posts are made of two pieces of porcelain rather than the three used previously. Regular hex head bolts replace the Allen head screws formerly used, and four of them assemble a stack instead of the 32 previously required. Elimination of joints increases stiffness and improves margins of safety over ratings. Less deflection under load assures better operation of switches and other equipment.

Portable Air Cleaner. A small, portable air cleaner developed by the Raytheon Manufacturing Company, Waltham, Mass., removes approximately 99 per cent of all smoke, dust, pollen, and even some types of bacteria from the air in a room. The "Micronaire" cleaner is an electrostatic precipitator which traps all air-borne

(*Continued on page 44A*)

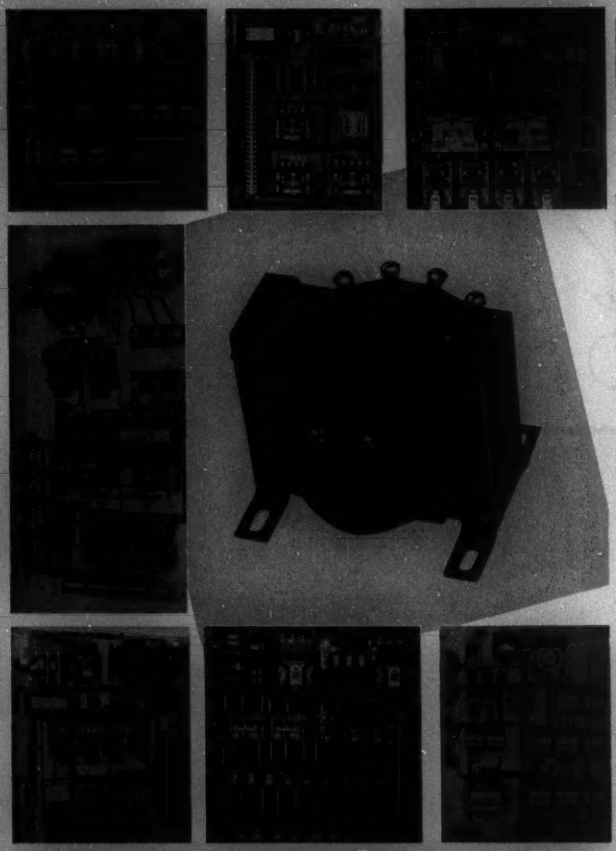
DISTRIBUTION LOWEST COST?



Inverted Interrupters are readily accessible for operation with a hook stick.

Single-pole Load Interrupters for vertical mounting—14.4 kv 600 amp.

S&C ELECTRIC COMPANY



RATED VOLTAGE MAINTAINED DURING SEVERE OPERATING CONDITIONS with

HEVI-DUTY.

CONTROL CIRCUIT TRANSFORMERS

Hevi Duty Transformers are specifically designed to reduce the voltage drop to the holding coils of contactors, relays, and similar equipment at peak in-rush periods. Well anchored coil terminals eliminate the need for terminal boards. Notice how these compact, neat appearing Hevi Duty Transformers save valuable panel space. Sizes 20 V.A. to 10,000 V.A. We are experienced in the production of specialty transformers.

Write for data and regulation curves — Bulletin T-5111.

HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively

Dry Type Transformers *Constant Current Regulators*

(*Continued from page 36A*)

particles by a form of magnetic attraction. It plugs into any handy outlet and affords quick relief to asthma and hay fever sufferers and to business people in smoke-filled rooms, and is valuable in laboratories where a sterile atmosphere is required or in any application where dust specks present a problem.

Industrial Rectifier Tube. National Electronics, Inc., Geneva, Ill., has developed a new quick-heating rectifier tube for industrial control applications. This tube, designated *NL-616*, is rated at 2.5 amperes direct current and 30 amperes peak current. The high peak current rating permits use in motor speed control applications requiring high starting currents. *NL-616* is gas and mercury filled for quick starting and long life. Other ratings are: filament voltage, 2.5 volts; filament current, 9 amperes; peak inverse voltage 1,250.

Miniature A-C Motor. A subminiature, either 400- or 60-cycle, a-c motor has been developed which is compact and precision-made for applications where size, weight, and high performance are the governing factors. Protection for military environmental conditions has been considered in the design. The motors can be wound for single, two, or three phases, and can be furnished as an induction or hysteresis motor. The characteristics of these motors can be readily modified to cover a wide range of application requirements; for specific applications, details should be submitted to the factory for determination of the final design. Additional information may be obtained from Yale J. Holt, Globe Industries, Inc., 1784 Stanley Avenue, Dayton, Ohio.

Variable-Frequency Electronic Generator. The Model *1420-B* Variable Frequency Electronic Generator developed by Communication Measurements Laboratory, Inc., Plainfield, N. J., is a versatile power source for use in the development or production testing of equipment operating over a range of power supply frequencies. Frequency range of the internal oscillator is 50–6,000 cycles with external oscillator 25–20 kc. Power output is 300 volt-amperes. Distortion is under 2 per cent. Regulation is less than 2 per cent no load to full load. Nominal output voltages are 80, 120, 135, 215, 255, and 270 volts. Twelve-decibel inverse feedback insures low dynamic output impedance.

Center Break Switch. A completely redesigned type *DR* center break air switch has been announced by the R&IE Equipment Division of I-T-E Circuit Breaker Company, Greensburg, Pa. Featured on the switch are design characteristics common to other R&IE horizontal and vertical break switches. Sealed pressure hinge contacts have replaced flex connections at the swivel jaw and swivel hinge terminals. Pressure finger jaws designed with a combination copper and beryllium copper provide for high conductivity, strength, re-

(*Continued on page 50A*)

Here's what we mean by SIMPLE!

To change the ratings on this regulator, just move two limit switch pins ✱

DO A WEEK'S job in minutes! With the *Vari-Amp* feature on Allis-Chalmers single-phase power regulators only three simple steps are needed to change ratings.

All you do is (1) open the position indicator window, (2) place the "raise" and "lower" limit switch pins in desired positions, and (3) close the window. That's all there is to it! No need to take regulator out of service. No electrical connection to make. No complicated adjustments or wiring. All other single-phase power regulators require 10 complicated, time-consuming operations to change windings.

Get Five Ratings in a Single Unit

With Allis-Chalmers single-phase power regulator you get five ranges of operation instead of the usual two. In most cases, initial cost is lower because of this flexibility. And, you can increase capacity with only a proportionate decrease in range of regulation. The *Vari-Amp* feature also provides extra short-circuit capacity.

Get complete facts on the convenience, flexibility, and reliability of Allis-Chalmers single-phase power regulators. Call your nearby Allis-Chalmers office or write Allis-Chalmers, Milwaukee 1, Wis., for Bulletin 01B6065C.

A-4462

ALLIS-CHALMERS

Originators of 5/8% Step Regulation

A-C ALLIS-CHALMERS

NOW

Precision Attenuation to 3000 mc!

TURRET ATTENUATOR featuring "PULL-TURN-PUSH" action

FREQUENCY RANGE:
dc to 3000 mc.
CHARACTERISTIC IMPEDANCE:
50 ohms
CONNECTORS:
Type "N" Coaxial female fittings each end
AVAILABLE ATTENUATION:
Any value from .1 db to 60 db
VSWR:
<1.2, dc to 3000 mc., for all values from 10 to 60 db
<1.5, dc to 3000 mc., for values from .1 to 9 db
ACCURACY:
±0.5 db
POWER RATING:
One watt sine wave power dissipation

Send for free bulletin entitled "Measurement of RF Attenuation"

•

Inquiries invited concerning pads or turrets with different connector styles

STODDART AIRCRAFT RADIO Co., Inc.

6644-B Santa Monica Blvd., Hollywood 38, California · Hollywood 4-9294

(*Continued from page 44A*)

siliency, and high thermal capacity. The new switch is built in voltages from 7,500 through 161,000 with current ratings from 400 through 1,200 amperes.

Automatic Tester. The Industrial Test Equipment Company of 55 East 11th Street, New York 3, N. Y., has developed the Automatic Hi-Pot Tester Model *A* which automatically tests, in sequence, the dielectric strength between any ten conductors and indicates the location of breakdown when it occurs. The test interval can be accurately controlled up to 120 seconds, and the applied voltage is continuously variable up to 2,000 volts rms. A dual-scale hand-calibrated meter insures accurate setting of the test voltage. High sensitivity to breakdown is made possible by employing a specially designed relay in series with the high-voltage circuit. It can be used for production testing of slip rings, commutators, cable connectors, synchros, transformers, and similar devices. Other test positions can be supplied on request.

Subminiature Preamplifier. The Glennite Model *F 410* subminiature preamplifier was designed by the Gulton Manufacturing Corporation, Metuchen, N. J., for use with missiles, aircraft, and other devices where size, weight, and power consumption are of paramount importance. The 6-ounce unit is $2^{11}/_{16}$ inches wide, $1^{3}/_{16}$ inches high, and $2^{1}/_{4}$ inches long. Power requirements are: filament, 6 or 28 volts; plate, 105–250 volts. A 4-tube unit, the device incorporates a cathode follower input to give an input impedance of 100 megohms. It has selective gains of 10, 30, 100, and frequency response from 5 to 20,000 cps.

High-Speed Gear Unit. The Philadelphia Gear Works, Inc., Philadelphia, Pa., has developed a completely new and improved line of Hi-Speed Gear Units for speed reduction and increased service. Rotating speeds up to 9,000 rpm and pitch line velocities to 10,000 feet per minute can be accomodated without modification. The units are manufactured in 17 sizes for ratings up to 7,000 hp and are available in any specified ratio from 1:1 up to 10:1. Gearing is of the double opposed helical type having teeth hobbed and precision shaved and is dynamically balanced to provide vibration-free power transmission at even the highest rotating speeds. For further information write for catalogue *HI-542*.

Lightweight Distribution Transformer. A new lightweight 167-kva single-phase distribution transformer is now being produced by the Line Material Company, Milwaukee, Wis. The unit, which utilizes an obround tank, offers reduction in weight and size, and provides a compact, streamlined appearance. It is available in all standard primary voltage ratings through 13,800 volts and may be pole-mounted. All single-phase transformers, 5–100 kva, will be redesigned to incorporate the advantages offered by the obround tank.

(*Continued on page 52A*)

announcing . . . a new source for

Permalloy POWDER CORES

MAGNETICS inc.

Performance-Guaranteed

Here's something to ring bells about, for Magnetics, Inc., the nation's largest manufacturer of tape wound cores, is now licensed by the Western Electric Company to manufacture molybdenum permalloy Powder Cores.

So now Magnetics, Inc. brings to powder core users the same "Performance-Guarantee" which has already provided a major free bonus to users of our tape wound cores, bobbin cores, magnetic shields and magnetic laminations. This is a guarantee of performance *to your specifications.*

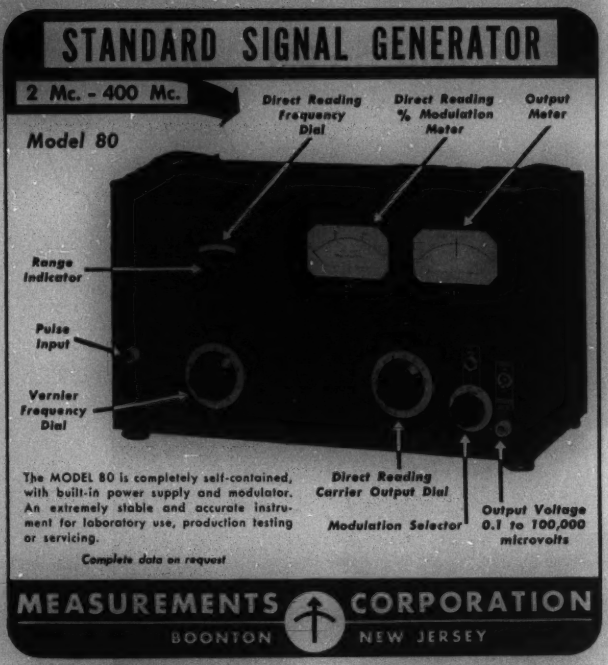
"Performance-Guarantee" is your assurance of savings in production and assembly. It costs you no more . . . our prices are standard in the industry . . . so make sure your next permalloy powder core order reads, "Magnetics, Inc. Performance-Guaranteed."

READILY AVAILABLE Why wait to have your Performance-Guaranteed Powder Core orders filled? Our expanded production facilities can have your order on its way almost as soon as it arrives. And send for our Bulletin PC-103 today so that you're ready to order Performance-Guaranteed Powder Cores as soon as you need them.

Write on company letterhead

MAGNETICS inc.

DEPARTMENT EN-19, BUTLER, PENNSYLVANIA


STANDARD SIGNAL GENERATOR
2 Mc. - 400 Mc.
Model 80
Direct Reading Frequency Dial
Direct Reading % Modulation Meter
Output Meter
Range Indicator
Pulse Input
Vernier Frequency Dial
The MODEL 80 is completely self-contained, with built-in power supply and modulator. An extremely stable and accurate instrument for laboratory use, production testing or servicing.
Complete data on request
Direct Reading Carrier Output Dial
Modulation Selector
Output Voltage 0.1 to 100,000 microvolts
MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

AVA

TO 5,000 VOLTS & TO 2,000,000 CM!

AVA POWER CABLE BY CONTINENTAL WIRE

has long been known as one of the *highest rated temperature* cables made . . . Today, Continental AVA also supplies the *highest current capacities* in the industry (servicing from 600 to 5,000 volts) — and in the *widest range of sizes* available (18 AWG to 2,000,000 CM inclusive) . . . Write for stock-catalog, or about your particular requirements — special wires manufactured to meet specific conditions.

HEAT- & MOISTURE-RESISTANT WIRES, CABLES & CORDS for

Air Conditioners, Airplanes, Bakeries, Bake Ovens, Ballast Transformers, Boiler Rooms, Busses, Central Stations, Clothes Dryers, Commercial Refrigerators, Cranes, Dry Kilns, Electric Furnaces, Electric Motors, Electric Ranges, Electronic Equipment, Hair Dryers, Heat Controls, Heating Elements, Infra-red Heat, Lighting Fixtures, Locomotives, Mercury Switches, Motion Picture Machines, Oil Burners, Panel Boards, Paper Mills, Power Houses, Pyrometers, Radios, Range Lights, Range Timers, Resistance Soldering, Restaurant Equipment, Rheostats, Sewing Machines, Show Case Lights, Smokehouses, Soldering Irons, Spotlights, Stage Lights, Steel Mills, Switchboards, Table Stoves, Television Sets, Thermostats, Toasters, Waffle Irons, Water Heaters, *et cetera ad infinitum*.

CONTINENTAL WIRE CORPORATION

Plants at YORK, Pa., & WALLINGFORD, Conn.

SALES: Box 363, Wallingford, Conn. Phone 9-7718 DEPT. M C E

(*Continued from page 50A*)

Rapid Production Bridge. The Freed Type *1870* Incremental Inductance Comparison Bridge is designed for rapid testing of transformers and chokes under actual operating conditions. The instrument consists of a variable 0–500-ma d-c supply, a 60-cycle 0–135-volt a-c supply, a comparison circuit, and a vacuum-tube voltmeter. A jack is incorporated for connecting an external oscillator to supply other test frequencies. All controls and power supplies are contained in one unit and the instrument operates from a 100–125-volt 50–60-cycle line. For further information write directly to the manufacturer, Freed Transformer Company, Inc., 1715 Weirfield Street, Brooklyn 27, N. Y.

Home Light Control. Luxtrol, a development in home light control permitting the setting of the light intensity of lamps to any value from complete darkness to full brightness, is being marketed by The Superior Electric Company, Bristol, Conn. Each unit, operating on the dimmer principle used in theaters, can handle any number or combination of lamps, colored or uncolored, up to a load of 360 watts. Essentially, the Luxtrol unit is a 360-watt variable autotransformer operating from a 120-volt a-c source. A movable brush contact rides on a bared portion of the winding. Rotating the contact arm by turning the knob produces any desired light intensity. The units are available nationally through architects, builders, electrical contractors, and distributors.

50-Ampere Recloser. A new 50-ampere recloser (type *50-GR-3*) for use on 2.3- to 15.5-kv distribution systems is available from the Westinghouse Electric Corporation. The new 3-pole unit is an addition to the present line of 100-ampere reclosers, and is designed for use where the larger interrupting capacity is not necessary.

The *50-GR-3* is suitable for manual or solenoid operation. For further information, write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

TRADE LITERATURE

Transistor Bibliography. "Transistors and Their Applications: A Bibliography, 1948–1953" has been compiled by students, under the direction of Alan R. Krull, using the facilities of the Technological Institute Library (Northwestern University Library), Evanston, Ill. Together with its appended supplement and within the confines of the title, the bibliography is fairly comprehensive. Some references dealing with the processing and purification of germanium, the principles of germanium diode action, and other subjects which appear to be related only indirectly to this topic have been included when the individual article was believed to have sufficient bearing. Some pre-

(*Continued on page 62A*)

Chemical Plant Power Cable Failures STOPPED

with insulation of BAKELITE Polyethylene and jacketing of BAKELITE Vinyl Plastic

Fig. 1. Cable pit damage with cables racked. Original lead fire-proofed insulation is destroyed. Cables replaced with

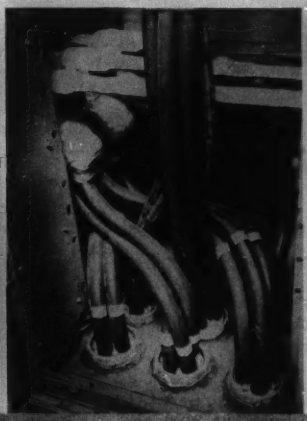


Fig. 2. Cable splices are wrapped with polyethylene tape, then covered with vinyl tape and friction tape coated with waterproof sealing compound.

Fig. 3. Concrete encased fiber duct after ethylene dichloride attack. Old cable insulation was destroyed. BAKELITE Polyethylene has never failed.

One of the toughest proving grounds for cable insulation is the big Texas City plant of Carbide and Carbon Chemicals Co., a Division of Union Carbide and Carbon Corporation. That's why this plant has installed only cable insulated with BAKELITE Brand Polyethylene jacketed with BAKELITE Brand Vinyl Plastic in the six years this combination has been available.

In one instance, cable insulated with BAKELITE Polyethylene was installed after some accidental spillage of a chlorinated hydrocarbon ate through a 4-in. fiber duct encased in reinforced concrete. The old insulation had been literally dissolved (fig. 3). Even though some of the chemical still remained in the duct, the new installation has served without failure for four years.

Another breakdown occurred when air was circulated through certain conduits to prevent overheating. It carried some oil fumes that caused complete deterioration of the rubber-type compound covering the cable. At another point, high-alkaline water seeped into the duct run, corroding the lead sheath and penetrating to the conductors.

In contrast, insulation of BAKELITE Polyethylene and jacketing of BAKELITE Vinyl Plastic have proved themselves with years of trouble-free service. Write Dept. AU-66 for copy of "KABELITEMS" No. 54 which describes the advantages and applications of these materials.

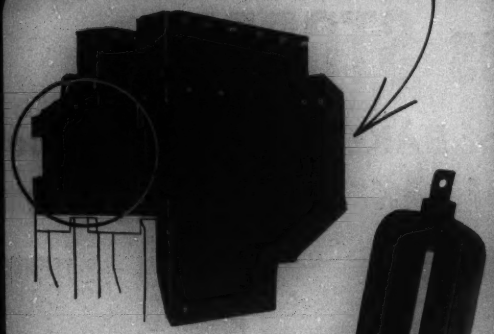
BAKELITE BRAND PLASTICS

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

The term BAKELITE and the Trefoil symbol are registered trademarks of U. C. C.

IDEAS *in the making*



ENCAPSULATED MAGNETIC BLOWOUT COIL FOR CIRCUIT BREAKER . . .
made with **ARALDITE** *Epoxy Resins*

PROBLEM. To develop an insulated blowout coil having high *dielectric* and *mechanical strength* and *thermal stability*.

SOLUTION. The unit was vacuum cast by I. T. E. Circuit Breaker Co., using an ARALDITE Epoxy Resin further compounded by Houghton Laboratories, Inc.

For details on Araldite Epoxy Resins formulations . . . Ciba Company Inc., Plastics Division, 627 Greenwich Street, New York 14, N. Y. or . . .

Aries Laboratories Inc. . . . . New York, N. Y.
Emerson & Cummings Inc. . . . . Canton, Mass.
Furane Plastics Inc. . . . . Los Angeles, Calif.
Houghton Laboratories Inc. . . . . Olean, N. Y.
Rubber & Asbestos Corp. . . . . Bloomfield, N. J.
Rezolin Inc. . . . . Los Angeles, Calif.

CIBA
ARALDITE® Epoxies

(*Continued from page 52A*)

1948 literature references which outline the developments leading to the transistor have been included also.

Water Pollution. A new publication entitled "Clean Waters—and How to Get It" has been announced as available from the General Electric Company, Schenectady 5, N. Y. The 2-color 34-page bulletin, designated *GEA-6096*, is designed to help civic leaders, municipal officials, and sewage treatment experts dramatize to their communities the urgency of providing proper sewage treatment and how to get it. It contains facts on water pollution, a 4-step community action course to fight pollution, examples of successful municipal campaigns, and methods of maintaining public support for such programs.

Polyphase Watt-Hour Meters. A new booklet describes the design, construction, and performance of types *DSP* and *DAP* polyphase watt-hour meters, most recent additions to the Westinghouse meter line. The new meters offer an extended load range for metering both present and future loads, and straight-line accuracy is maintained up to 667 per cent of rating. Performance data are presented graphically and technical data are presented in tabular form. For a copy of the booklet, *B-6398*, write to the Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, Pa.

Glossary of Iron Castings. This 36-page glossary explains over 150 technical terms commonly used between suppliers and users of ferrous and nonferrous castings. It is offered to increase mutual understanding and promotes greater accord in working out procurement of satisfactory and improved castings. Write to International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

Turbo-Products Catalogue. William Brand and Company, Inc., of Willimantic, Conn., and Chicago, Ill., manufacturers of electrical insulating materials, have announced publication of a new turbo-products catalogue that combines easy-to-use features and helpful information with respect to wire and tubing, an appendix which defines technical terms, and tables of insulation resistance temperature coefficients and temperature conversion. Ask for "Catalog '54."

Surface Condensers. The latest data and technical information on problems of power plant engineering are contained in a 20-page booklet released by Allis-Chalmers on the proportioning of surface condensing equipment. The booklet describes factors entering into the proportioning and selection of surface condensers, provides formulas for use in calculating the performance of a given condenser, and carries a variety of curves and tables for quick reference. Copies of "Proportioning of Surface Condensing Equipment," *19B8201*, are available from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.